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Report on Supplying the City of Ellsworth, Maine, with Pure Water

H. A. Hancox

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REPORT

— OF —

H. A. HANCOX, C. E.,

OF HUDSON, MASS.

ON THE SUPPLYING OF THE

CITY OF ELLSWORTH,

MAINE,

WITH PURE WATER.

ALSO AN

ESTIMATE OF THE COST OF BUILDING THE SAME,

ACCOMPANIED BY

MAPS, PLANS AND PROFILE.

HUDSON:

THE ENTERPRISE STEAM JOB PRINT.

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*REPORT OF H. A. HANCOX, C. E., OF HUDSON,
MASS., ON THE SUPPLYING OF THE
CITY OF ELLSWORTH, ME.,
WITH WATER.*

TO MESSRS. A. I. SAUNDERS, HON. JOHN B. REDMAN, F. B. AIKEN,
GEO. A. PARCHER, A. F. GREELY, MORRISON & JOY, LEWIS
FRIEND, H. C. FORSAITH, COL. C. C. BURRILL, A. H. NORRIS,
R. F. SUMNIMSBY, JOY & MORRISON, A. W. CUSHMAN, B. F.
GREY, A. M. HOPKINS, E. F. ROBINSON, H. M. & B. HALL,
OLIN M. DRAKE, J. T. HOPKINS, H. B. MASON, A. P. WIS-
WELL, W. M. HAINES, M. D., DAVIS AND SMITH, ROSCOE HOLMES,
L. A. EMERY, G. P. DUTTON, H. B. PHILLIPS, and others.

Gentlemen:—I have the honor to herewith respectfully submit for your consideration a plan for supplying the City of Ellsworth with pure water for domestic and industrial uses, as well as for the purpose of subduing fire.

Having been employed by you to make such explorations, investigations, and surveys as in my judgment seemed necessary to ascertain whether the scheme was feasible or not, and make an estimate of the cost of the same; I have accompanied this report with a carefully prepared estimate based upon instrumental work and illustrated by such maps and plans as appeared necessary to convey a comprehensive idea of the proposed system.

As the question is one of great local importance any digression on my part to present its many advantages in their true light I trust will be pardoned. On the one hand is the assumption on the part of the projectors of heavy financial obligations for the construction and maintenance of efficient works, while on the other are the numerous advantages to be gained only by having such works.

Selfishness and cupidity are the main sources of opposition to all public improvement and experience has shown that the friends of all enterprises of this kind have had first to meet and overcome this antagonistic element which exists wherever private interests are, or appear to be, sacrificed for the public good. Again there are others, who, through inadequate knowledge fail to grasp the question in its true light and consequently honestly but ignorantly oppose it on economical grounds. To these the presentation of a few statistics always prove of interest.

The most convincing argument, however, is for those who have any doubts as to its being a *paying* investment, to visit such towns as have them in operation and ask the people if they would part with them for twice their cost. The answer will invariably be, "No."

WHAT WATER WORKS COST.

What water works cost must be determined by a comparison of the outlay with the benefits derived thereby. That those benefits are wide spread and far reaching, no one can for a moment doubt who will take the trouble to look into the question.

First, comes the great public and private convenience of having the water under constant pressure and always at hand. This cannot be estimated by any fixed standard as it enters so largely into all domestic purposes and industrial pursuits. The saving of labor alone in the conveyance of water from wells to the upper floors of city tenements, is a matter of considerable importance.

Second, comes its value as a sanitary scavenger. When connected with a public sewerage system it contributes largely to the promotion of public health in a city or town, not only by carrying off the waste slops and cesspool accumulations, but in doing away with the danger of contaminated wells.

Third, comes its office as a fire-protecting agent, which is so valuable that often the amount of property saved annually would more than pay the first cost of a system. I need refer here to but one of many experiences to demonstrate its value as being the most effectual and economical agent in the protection of property from destruction by fire:

"At Columbus, Ohio, the average loss by fire for the four years preceeding the completion of the public water works was 65-100 of one per cent. of the valuation. The average loss during the first four years after the completion of the works was 13-100, and during the fifth year, from April 1st, 1875, to April 1st, 1876, was 11-100 of the valuation."

These statistics show a saving in the first four years of upward of one-half million dollars.

Fourth, It is a stimulus to the prosperity and developement of a city. *Capital is wary of investment where the elements of safety and health are lacking.* Its incidental advantages are many. As an additional security against fire, it enhances the value of property along the line of its arteries, while there is also a perpetual reduction in the yearly insurance rates. In the recently adopted schedule of the National Board of underwriters, there are so termed *additions* to a minimum standard rate in a standard city, which is provided with a good water supply, fire alarm, police, etc., as follows, termed deficiency charges:

| | |
|--|----------|
| Minimum standard rate of insurance of a standard building, 25 cents. | |
| If no water supply, - - - - - | add 15 " |
| If only cisterns or equivalent, - - - - - | " 10 " |
| If system is other then gravity, - - - - - | " 05 " |
| If no fire department, - - - - - | " 25 " |
| If no police organization, - - - - - | " 05 " |
| If no building law in force, - - - - - | " 05 " |

The financial value of the enhanced fire risk, as deduced by the Board from an immense mass of statistics, and the additional premium charged on the most favorable buildings, is sixty per cent. without good water works, and forty per cent. if only fire cisterns are provided. The rates of insurance in Ellsworth are very high and if the experience of other cities and towns be taken as a criterion the reduction in premiums will go far toward defraying the interest on cost and running expenses. It is often advanced in argument that the expense often over-runs the original estimates and no one can foresee the cost. This is not always so and the impression generally originates in the additional extensions sometimes ordered during the progress of construction. M. M. Tidd built the Lewiston, Me., system for \$55,000 less than his estimates, and the works at Natick, Mass., for several thousand less. The Newton system was built for \$80,000 less than the engineers estimates, and the water works at Woodstock, N. B., were awarded to Burrell-Johnson Iron Co., for exactly the engineers (Crafts & Forbes) estimates.

ITS VALUE AS AN INVESTMENT.

If we assume that experience is the most reliable teacher the question of its value as a remunerative investment has been fully and satisfactorily answered. In this particular case it can only be determined by comparison. Where there is a population of five thousand or upward there is generally no doubt in regard to its being a paying investment. But where towns are smaller than that, circumstances have to be considered, such as the cost of constructing a system, the probable future patronage, and whether built by a stock company or a municipality. This, however, must not be construed as an argument against small towns and cities investing their capital in a public system.

Nearly all of our American water supply reports show an annual income in excess of the operating expenses and interest on capital invested. The writer is informed on good authority that Auburn, Me., with a population of 3000 has invested nearly \$150,000, in her water system and last year declared a dividend of 36 per cent. Much smaller cities than Ellsworth have invested in public water works and found the investment a financial success. Among them may be mentioned Suspension Bridge, N. Y., population 2510; Sedalia, Mo., population 1100; Abilene, Kansas, population 2047; and Fargo, Dakota, population 2700. To ascertain its value as an investment it is necessary to arrive at an approximate estimate of the future patronage and obtain with some degree of accuracy the probable income of your system. The annual income of works that have been in operation for a number of years in Boston, Cambridge, Fall River, Waltham, Lowell, New Bedford, Lawrence, Newton, Brookline and Taunton average \$16,000 for each service in use. Boston receives \$21.15 a service, and Waltham, a town of 12000 inhabitants, receives \$16.21. Brookline a town of 9000 inhabitants, receives \$14.29; Marlboro, Westboro and other smaller towns in Massachusetts receive only \$7.00 per service in use. Statistics gathered from the annual reports of the above

towns for a number of years show that "in the first year after the works go into operation, forty per cent. of the inhabitants are water takers, and after three years from two-thirds to three-quarters." It is usual to reckon an average of six persons to each service.

But outside of all pecuniary gains, the unquestioned and general benefits accruing to the public far exceed in their real value the moneyed returns, and these should always be considered in estimating the *actual* worth of a system.

SELECTING A SUPPLY.

As in your case circumstances would not warrant the introduction of an expensive system, the importance was felt of selecting a supply that by its proximity, elevation, quantity and quality, seemed to be both economical and practical. To this end an exploration of the surrounding country has been made and a careful examination of all the water-ways and sources of supply that might possibly be utilized for the purpose. In these investigations three things had to be kept constantly in view, namely:

First. The quality of the water at the present time and possibility of future pollution.

Second. The quantity required to meet all present demands and future emergencies.

Third. The natural difficulties to be overcome in constructing and maintaining efficient works.

But in order to fully understand the causes that lead to the adoption or rejections of certain sources of supply it is necessary for you to become familiar with the essentials of an efficient system. This portion of the subject may be sub-divided and classified under the following captions.

(I.) The Essentials of an Efficient system.

(II.) The Sources of Supply.

I. THE ESSENTIALS OF AN EFFICIENT SYSTEM.

In order to have a good system of water works it is necessary, (1) the water be pure, soft, and colorless, to such a degree as will render it suitable for all domestic and sanitary purposes, besides being palatable, healthful, and well adapted for use in all branches of industry. (2). In quantity it should be ample for domestic service, industrial purposes, arresting or subduing conflagrations, and supplying the general public use, such as fountains, baths, horse-troughs, sprinkling streets, etc. (3). The storage facilities must be sufficient to preclude the possibility of a failure of the supply in extreme droughts. (4). The water must be obtained, or delivered at an elevation sufficient to carry it above the roofs of the highest houses in the environs of the city proper. (5). The general arrangement of the distribution system, gates and hydrants, should be such as to insure a free and ample flow sufficient to meet the demands of at least three fire engines at the same time, and at any time, in addition to the ordinary demand.

Various systems of water works are often possible at the same place, while again one may be advantageously introduced where another would be impossible, or prove impracticable. The systems generally employed are designed as follows:

I. **PUMPING WORKS, WITH A DISTRIBUTING RESERVOIR.** This design, which is very generally used, has the water forced by mechanical process up into an artificial reservoir located upon some elevation where it supplies the distributing system by gravity.

II. **PUMPING WORKS WITHOUT A RESERVOIR, AND USING A STAND PIPE.** This design is resorted to in level countries where no hills are convenient upon which to construct an empounding reservoir, and which is replaced by a stand-pipe. It is also employed to produce an uniform pressure. The pipe consists of a cylindrical tube of riveted metal plates, generally encased in masonry, or otherwise housed in the colder latitudes, to protect it from frost, and carried to a sufficient height to obtain the requisite pressure. The water vibrates up and down in this immense column according to the rate of delivery and fluctuations of the demand.

III. **PUMPING WORKS WITHOUT EITHER RESERVOIR OR STAND PIPE, USUALLY CALLED THE DIRECT SUPPLY OR "HOLLY SYSTEM."** In this system, which is the most modern that has been introduced, the water is forced directly into the distributing pipes by pumping machinery which is peculiarly constructed for that purpose. To guard against contingencies the pumps are so arranged that the breaking of a part does not disable the whole. It is now in use in about one hundred cities and towns on the American continent, among them Bangor, Buffalo, Rochester, Lockport, Memphis, Sacramento, Indianapolis, Taunton, Atlanta and many others. They have, I believe, given general satisfaction.

IV. **GRAVITATION WORKS, WITH OR WITHOUT A DISTRIBUTING RESERVOIR.** Here they utilize the law that actuates falling bodies, and this system can only be introduced where nature has supplied the water, or it can be empounded, at a sufficient altitude to flow naturally into the distributing pipes. This system was resorted to in ancient times before the advent of hydraulic mechanism; and, where an ample supply can be obtained under favorable conditions in proximity to the demand, it has a preponderance of advantages over all other systems, as it materially lessens the cost of maintenance. This is understood by all engineers, and advocated by them where possible to introduce it, unless they are interested in some mechanical pumping apparatus.

WHAT CONSTITUTES WHOLESOME WATER.

Wholesome water does not always imply chemically pure water, but water devoid of harmful impurities. The composition of pure water consists of two parts hydrogen to one of oxygen, or by weight, hydrogen 11.1, and oxygen 88.9. These gasses have entered into a subtle and most wonderful union, the mystery of which no human mind has yet fathomed. We know that the solvent powers of this combination exceed that of any other known agent, and consequently through its capacity to overcome the cohesive force in matter and repulsive force in gases, it is

rarely found in a chemically pure condition, but generally holds in solution more or less mineral and organic impurities. This fact seems to indicate that in the great economy of nature it has been ordained that man should not receive water in a chemically pure state. What, however, are the admixtures that are harmful, and what harmless are to be determined, and it is to be deplored that scientific research has covered only a small part of this wide field, and much yet remains wrapt in mystery and left to speculation and conjecture.

Sanitary and medical authorities disagree upon the limit where water becomes sufficiently noxious and impregnated to be rejected, but experience and chemical analysis has supplied an accumulation of statistics that enables the investigator to determine with some degree of accuracy what constitutes good, potable water.

IMPURITIES OF WATER.

The impurities of water are many, as nearly all substances, animate and inanimate contribute them, as well as the gasses in the elements. They may, however, be classed as vegetable organic impurities, animate organic impurities, and mineral impurities.

VEGETABLE ORGANIC IMPURITIES. All natural water abounds with more or less vegetable organism and in every lake, spring and stagnant pool microscopic fungi vegetates. This wonderful hortulan world contains alga that thrives in abundance in all water under all climates, while again there are others peculiar to water of certain quality and temperature only.

A learned writer says the grade and character of the growths in fresh water are generally good tests of the quality of the water. This knowledge assists us in determining what constitutes wholesome water, as the purer and better the quality of the water, the finer the fibre structure of the vegetation and superior the organic life that frequents it.

Where waters are drawn down in the summer and the shallow, muddy bottoms of the bays are exposed to the hot sun, spontaneously luxuriant vegetation springs into existence, and the more rapidly it develops, the more quickly it decays, emanating gases that permeate the water affecting its quality to a noxious degree.

Again, in stagnant ponds and shallow, still water, with bottoms covered with illuvial deposit, the conditions are most favorable for stimulating vegetal life and producing the consequent rapid decomposition resulting from its accelerated growth. There thrives the dense, slimy *oscillatoria* and light green *zygenemas* so common in quiet water. Desmids, algæ and fungi make their appearance during the spring, summer and autumn, and the noctos, a plant peculiar to New England ponds, imparts the green scum so often seen floating upon the surface of shallow basins. This, with the spongilla and anaboema, those troublesome little plants that impart the "cucumber flavor" to the Sudbury basins of the Boston Water Works, are the most important.

ANIMATED ORGANIC IMPURITIES. The conditions that are favorable for the growth and multiplication of aquatic vegetable life are equally suited to the abundant propagation of animalcules and tiny infusoria, and every drop of stagnant water teems with invisible animal life, ranging from the energetic little creatures like the gonia, vorticella and volvox-globata that battle with each other for existence, down to the quiet fresh water sponge, monads and microscopic zoophytes or plant-animals.

It is supposed that these minute creatures feed upon the vegetable impurities to that extent that their presence indicates the existence of such impurities. But whether so, or not, I am convinced by observation that both are associated with a low order of animal life of larger growth, which can be relied upon as a general guide to the quality of the water they frequent. Where lizards and leeches swarm and fish will not live, the water should be rejected at once. Where a fish known as the horned or mud-pout alone lives, the water is better, but still unfit for use. The pickerel indicates good water, and where brook trout live the water may be relied upon as of excellent quality.

MINERAL IMPURITIES. However pure the natural waters of the earth's surface, they all contain, in solution, mineral impurities that they absorb from the earth and the air. The most common of these are carbonates of lime, soda and magnesia, chlorides of sodium, calcium and potassium, and sulphates of lime, potash, soda, and oxide of iron. These are not all harmful. Calcium, magnesium, potassium and sodium are even considered beneficial unless they exist in too great a quantity. The presence of ammonia or nitrous acid is considered one of the most dangerous and "disease-producing-elements," and betrays contamination by organic matter, and if in a well or spring, it may generally be attributed to sewerage.

Dr. Lyon Playfair, of London, remarks: "The effect of organic matter in the water depends very much upon the character of that organic matter. If it be a mere vegetable matter, such as comes from a peaty district, even if the water originally is of a pale sherry color, on being exposed to the air in reservoirs, or in canals leading from one reservoir to another, the vegetable matter gets acted upon by the air and becomes insoluble, and is chiefly deposited, and what remains has no influence on health. But where the organic matter comes from drainage, it is a most formidable ingredient in water, and is the one of all others that ought to be looked upon with apprehension when it is from the refuse of animal matter, the drainage of large towns, the drainage of any animals, and especially of human beings."

THE PUREST NATURAL WATERS.

Research reveals that the purest and most healthful natural waters found upon the globe are those that come down in mountain streams, flowing over the granite ledges and gathering in the clean, rocky catchment basins. This water has passed through the process of distillation,

and condensing, falls through the humid atmosphere, which, on the higher elevations is generally more free from floating matter, and being precipitated upon the mountain slopes, gravitates into the natural depressions, or passing into the seams of anticlinal rock, again reappears farther down in springs which contribute to the natural waterways. Thus we find in the thousands of crystal lakes that glimmer among the wooded hills of Maine, water of remarkable purity, and generally conditions most favorable for utilizing it to supply the wants of man.

II. SOURCES OF SUPPLY.

The City of Ellsworth is so situated that the pressure would not be uniform owing to the great disparity between the higher and lower levels of the city, which is about 200 feet. This will render the pressure very light in the highest located residences, but fortunately the greatest pressure will be concentrated where it is required the most, namely: in the central and business portion of the city. This will have another advantage in reducing the weight of pipe a number of tons; as much lighter pipes can be used where the head is less.

Owing, however, to this unevenness, some difficulty was experienced in finding a supply, that, by its situation, could be utilized by gravity. The following named sources were examined, and all but one rejected for the reasons stated.

I. SIMMONS POND, by its proximity to the city, presents an advantage in that respect only found in Union River and Cards Brook; but reports are conflicting in regard to the quality of its water, and, as this is the most important essential, it is a sufficient reason why it should be rejected. An instrumental survey has never been made, so its altitude above the datum plane (post-office curbstone) is only approximately known, but that a pumping system would have to be introduced, if its waters were utilized, is evident from its location, which is down in a deep depression surrounded by a continuous chain of hills.

II. UNION RIVER, which is the nearest supply available, would have to be pumped either into an empounding reservoir, or by the direct-supply system into the pipes. But owing to the impure condition of the water which is, in the summer time, very dark with vegetable discoloration, no estimate was made of the cost to introduce it.

III. REED'S POND, which is the largest body in the vicinity of Ellsworth, has been carefully examined. The quality of the water would be considered good anywhere as it will favorably compare with most inland fresh-water lakes, and is even superior to many sources of supply adopted by some of our largest cities. But there are two important reasons for its rejection: First, its situation is bad as it would necessitate about six (6) miles of piping in a circuitous route in order to reach the heart of the city. Second, its altitude is not sufficient to obtain the required pressure by gravity. It would easily supply the main part of the city, but owing to the frictional loss, it would not be effective for extinguishing fires twenty-six feet above the railroad crossing at Main Street.

Its high water level above the datum plane is 130.83 feet.

IV. **LITTLE ROCKY POND** lies near the Dedham town line in juxtaposition to Reed's Pond, into which it discharges its surplus water. It is a small, deep basin surrounded by stony, timber-covered hills. The water is rarely disturbed by the wind, and the ice lays over it until late in the spring. The general conditions are similar to those of Simmons' Pond, and in warm weather the water has a flat, stagnant taste. This led to its rejection, as well as its distance from the city which is 10.25 miles. Its low water elevation is higher than any other water in the vicinity, except Branch Pond. It has an altitude of 196.03 feet above the datum plane, or 65.2 feet above Reed's Ponds.

V. **BRANCH POND** is a large body of water lying northwesterly from Ellsworth, and by its quantity, quality and altitude, seems best adapted to a public supply.

First, the quantity is more than ample as the total length is about seven miles, with an average width of nearly one mile. This gives a supply, so far, beyond all present and future demands, that there is no necessity of calculating the area of water-shed, amount of rainfall, proportional evaporation and infiltration involved in smaller supplies.

Second, the quality is excellent. Surrounded by a clean watershed of stony hills, mostly covered with forests and steep precipitous shores of metamorphic rock, no conditions could be found more favorable for pure, wholesome water. Little or none of the surrounding country is under cultivation, consequently the danger of contamination from fertilizers is avoided, and there are no manufacturies, or deadly sewers, to empty their noxious, disease-inducing dregs into its limpid depth. There on its broad expanse, nature is ever at work with rain, wind and sunshine, maintaining its natural purity. Its abundant inflow and outflow creates a perpetual circulation, while its deep coves and immense submarine springs, keep the water cool through the hot summer months.

Again its bold shores defy that organic growth which vegetates in more shallow water and pollutes with its decomposition; while its broad surface is stirred by the winds to a great depth, areating it, and permitting all gaseous impurities to escape.

Where the ledges do not confine it the wave-action has long since removed the soil from the shore leaving it paved with boulders and pebbles which the ice has crowded into a dense, close rip rap.

Third, the altitude is sufficient to supply by gravity the houses on the highest elevations in the suburbs of the city proper.

The low water level of Lower Branch Pond, where the gate-house will be established, is *two hundred and ten and six-tenths* (210.6) feet above the datum plane, or post-office curbing, in Ellsworth.

The coping above the foundation to Senator Eugene Hale's house, (which is on the highest elevation of any in the city) is one hundred and eighty-nine and seventy-three one-hundredths (189.73) feet above the datum plane, or twenty and eighty-seven one-hundredths (20.87) feet below the low water level of the pond.

ARRANGEMENT OF THE SYSTEM.

LOCATION OF CRIB-WELL. In a deep part of the channel of Lower Branch Pond, situated where it will be least likely to be disturbed or damaged by drifting logs or debris, during freshets, will be located a crib-well from which the water will pass into the main pipe.

This well will consist of a wooden chamber 8x10 feet, and 13 feet deep, built crib-fashion and surrounded by another crib much larger, so as to leave a space of four feet between them. The outer wall, which will be about three feet thick, will be framed loose, but securely, so as to permit the free passage of the water. The space between the inner and outer wall will be filled with broken stone, thus forming a filter through which the water will percolate and enter the inner chamber, or well, and from which it passes into the main pipe.

This filter relieves the water from all floating sediment, and supplies the place of more costly screens.

THE GATE AND GATE-HOUSE. The gate will be located within this well at the mouth of the main-pipe, and the gate-house will be directly above it, covering in area the well only.

MAIN PIPE. The main-pipe will be twelve inches in diameter, and will enter the well three feet from the bottom, which is planked over and secured by tie-rods to the flooring above, as per detailed plan. As there is six feet of water in the channel at lowest water this will give a covering of three feet, and during extreme floods, of ten feet over the main.

COURSE OF MAIN-PIPE. The proposed course of the Main down to the city is to follow the valley of Branch Stream down to nearly its confluence with Union River, thence in a box over Hall's Bridge, along the Shore Road a short distance, leaving it near Hall's mill, and crossing the intervening fields between there and State street, enter State street near its intersection with School street, and here dividing into two, eight-inch sub-mains, one pass down School and the other State, each eventually entering the Main street pipe, and thus creating a free, triangular circulation through the central portion of the distributing system.

Leaving Branch Pond, the main will pass through a natural depression between the hills where nature has made an outlet for the discharge of surplus water during flood-time. Crossing the road, it will also cross Branch Stream at this point where it can be sunk into the deep deposits of sawdust at trifling expense. Passing on, the preliminary line crosses a low, marshy flat through the woods and cuts, through a rocky knoll, enters an open field of Ransom Bonzy, and crosses the highway leading from the Branch road to North Ellsworth, about one hundred and fifty feet north of the Bonzy bridge. Beyond this, in the open grass-land, owing to the formation of the country, the line turns sharply to the right and passes over a low interval, climbs around a bold side-hill close to the stream, and runs through a long stretch of woods where there is a more level country, over some marsh-meadows, and after a number of slight deviations along a stony side-hill, with the general course in a

southeasterly direction, it emerges into the open country opposite the buildings of the Ellsworth Woolen Manufacturing Company. From here it enters the woods again, passes over a level stretch of country and hugging the right bank of Branch Stream, eventually crosses it about half a mile above Mr. Truworthy's, near whose house it passes and enters the road above Hall's bridge, near Mr. Moore's, where it becomes a part of the distributing system.

The distance from Gate house to Hall's bridge, is, by the preliminary survey, twenty-one thousand two hundred and fifty (21,250) feet, or four (4) miles one hundred and thirty (130) feet. From the Gate house to the centre of the city the distance is about twenty-five thousand and eighty (25,080) feet, or four and three-fourths (4 $\frac{75}{100}$) miles.

That a *twelve inch main* is ample to meet all present and future requirements is demonstrated in the following calculation:

A twelve inch iron pipe, 25,080 feet long, or four and three-fourths miles, with a head of 210 6-10 feet, will have an approximate velocity of 4 28-100 feet per second, and a pressure of 90 96-100 pounds per square inch of surface, less the frictional head. This will give an approximate discharge of 3 363-1000 cubic feet per second, equal to 25 155-1000 gallons per second, equal to 1509 3-10 gallons per minute.

Now, estimating that the future increase in population and consequent patronage may reach 5000 inhabitants with a daily consumption of 52 gallons per capita, it would then require 260,000, gallons per day, or approximately 180 1-2 gallons, or 24 1-10 cubic feet per minute, to supply the public demands outside of fire purposes. Taking this 180 1-2 gallons from the 1509 3-10 we have 1328 3-10 gallons surplus for extinguishing fires.

The actual amount consumed for fires during the year is insignificant as regards the quantity, but the pipes require a very large delivering capacity, as a hydrant under 90 pounds pressure will discharge through one hundred feet of rubber hose and one inch smooth nozzle, approximately 211 gallons per minute, or equal to 28 2-10 cubic feet per minute, which will be seen by comparison, is alone more than the entire amount consumed for all other purposes. But the average consumption of hydrants will not exceed 20 cubic feet, or approximately, 150 gallons per minute. This in 1328.8, gives a quotient of 8.8, and deducting ten per cent. for friction, etc., we have *eight hydrants* that can safely be relied upon to discharge 1200 gallons per minute, at the same time.

THE DISTRIBUTION SYSTEM. As I have accompanied this report with a plan showing the arrangements of distribution pipes together with the location of the stop-valves, little further needs to be said in explanation of this part of the system.

The stop-gates are so arranged that each section may be closed up for repairs, etc., without interfering with the free circulation of the rest of the system.

The piping here estimated for the distributing system probably covers a much more extensive field than is immediately required to meet the public demand, but it is essential to complete circuits and avoid

"dead ends" as much as possible, as sediment deposits gather in them and the water stagnates and permeates with its flavor the whole supply.

The hydrants will be located at such distances apart as will best protect property along the pipe-lines; and hydrants on the higher elevations, where the pressure is not sufficient to be utilized directly for fire purposes, will have a steam nozzle attachment.

The value of such a system will be partly realized when it is understood that a hydrant located anywhere in the business portion of the city will throw a jet through one hundred feet of rubber hose and a one inch brass nozzle, a vertical distance of *one hundred and twenty-five feet*, and a horizontal distance of *one hundred and sixty-one feet*.

A FIRE PROTECTING SYSTEM.

To so construct a system that it may be an efficient fire protection is no small part of the expense attending the introduction of a public supply, for, as before stated, the pipes have to be much larger than would be necessary to meet all other requirements.

It is customary, where a public system is built by a private company, to tax the town or city for the fire-hydrants in use. The Boston fire department pays annually to the water department about \$80,000 or at the rate of \$18.00 a hydrant. In Newton they pay \$45.00 per hydrant, per annum; and nearly all the large cities in Massachusetts pay an average tax of \$25.00. Some companies receive as high as \$60.00 per hydrant per annum; or with ten hydrants a mile, \$600.00 per mile.

THE ARRANGEMENT AT AUBURN, ME. A brief description of a scheme adopted at Auburn, Me., may assist to a solution of your problem. I give it as it was given to me as near as I can recall it, by a member of their Water Board.

That an understanding might be arrived at between the town authorities and the private company who built the water works, it was arranged that the company should pay the entire expense of constructing the system so far as was necessary to meet all public demands outside of fire purposes. This does away with the cost of the larger pipes necessary to bring an ample supply to extinguish fires, also the cost of hydrants and the expense attending their attachment to the system.

The town, on the other hand, was to assume the expense of hydrants and the *difference* in cost of pipes and placing them. This gave them an efficient fire system under municipal control, and they have only to pay their proportion of the expense of maintenance, which, with a gravity system, would be insignificant.

When we consider that some cities put in expensive water works for fire purposes alone, the wisdom of a town, in taking advantage of a prospective system to co-operate with them and obtain control of the fire department, will be seen at once.

The strongest argument in favor of this arrangement lays in the more liberal distribution of hydrants under municipal management, and the consequent additional security to property this affords; for after the first cost there would be no expense attending them, and the authorities

would be induced to put in more hydrants than would otherwise be established. The abolishment of the hydrant tax, which has been heretofore shown as being quite a burden on some cities, would be a great saving, as many companies would naturally charge enough to receive some *profit* upon the capital invested in that *department* of the works, and that profit is hereby saved. Again, where a city or town does not feel able to assume a public debt sufficient to put in a public system, and yet realize their need of such a system, this is an excellent way to bridge the difficulty, as by it they are able to compromise and assume a part of the expense, and control *that part of the system which they should control*.

GENERAL CLOSING REMARKS.

I shall include in my estimate a cast iron pipe, coated by the Smith process. This has been in recent years almost universally adopted by all larger cities and towns.

The cement lined wrought iron pipe, as usually made, is in cost about 20 per cent less than the best quality of cast iron, but it has not given general satisfaction.

The usual process employed was first introduced I believe by Jonathan Ball, and laid in Saratoga, N. Y., as early as 1845. At the breaking out of the rebellion in 1861, pig iron arose from \$18.75 to \$73.62 per ton during the three years of the conflict, and so much less was the first cost of cement lined pipes at this time, that the business received an impetus and almost from necessity they were adopted regardless of comparative merits.

Many of the cities that first employed it, as Charlestown, Portland, Cambridge, Worcester and Fitchburg have since replaced it with cast iron pipe. That much of this dissatisfaction arises from carelessness both in the preparation and the laying of these pipes is evident, but to exercise the necessary care will bring the cost nearly up to that of cast iron at its present low rate. When properly made and laid it will stand well the tests of time. The writer was recently pointed out the route of a cement lined pipe in Stonington, Conn., that had been down more than thirty years, and had given no trouble except where it passed under the track of the Stonington and Providence Railroad, when, through vibration produced by passing trains, it has sprung a leak twice during that period. Waltham, Mass., employs it to-day, but manufactures it themselves under the personal supervision of their Engineer, and they exercise great care in the laying of it, which so far in their experience has proved highly satisfactory.

No better time than the present could be found to take hold of this enterprise. The extremely low price of iron has never heretofore been known and the saving in the cost of pipe alone in purchasing at present rates as compared with what it would have cost one year ago, amounts to \$9,318.00.

That Ellsworth is in danger of an extensive conflagration with the present limited fire extinguishing resources no one will question, and I

could add little to further impress this fact upon you. The recent disastrous fire that consumed the City Hotel; the giving out of the fire cisterns before the flames were subdued, and the necessity of utilizing one engine to pump water from the river to supply the other, demonstrated to the most obtuse person present the fact that fortunate circumstances alone have favored you in the past.

Your beautiful little city is well situated for the location of important industries. You have a grand water power in Union River, and by water and rail easy access to the markets of the world. With the blessings of a public water system to protect property and supply the manifold wants of a growing community, you offer inducements that, sooner or later, would attract manufacturers to establish their enterprises with you.

In submitting the following estimate of cost I have based my computation upon the figures of reliable contractors who are willing to contract to furnish the materials and perform all of the labor for the prices herein given.

I would add, however, in explanation, that I believe these figures can be materially reduced by shifting the pipe in a few places into the bed of Branch Stream and thus avoid a part of the ledge excavation, for which I have had to allow a liberal contingency, as it is impossible without going into the expense of test-pits, to ascertain with any degree of accuracy the amount of rock that would be encountered in trenching.

Where ledge cutting occurs upon the streets it will add \$1, per lineal foot to the cost of the pipe line.

ESTIMATE OF LINEAL FEET OF PIPE REQUIRED ON EACH STREET.

| NAME OF ST. | FROM | TO | 12 in. PIPE. | 10 in. PIPE. | 8 in. PIPE. | 6 in. PIPE. | 4 in. PIPE. |
|-----------------------|----------------|----------------|-----------------|-----------------|----------------|----------------|----------------|
| Main st. | Mt. Desert st. | Grant st. | | 1868 | | | |
| Main st. | Grant st. | Laurel st. | | | | 1690 | |
| Main st. | Mt. Desert st. | Top of Hill. | | | | 1700 | |
| State st. | Main st. | School st. | | | 1540 | | |
| State st. | School st. | Oak st. | | | | 1645 | |
| School st. | Main st. | State st. | | | 1470 | | |
| Oak st. | Main st. | Birch Ave. | | | | 1620 | |
| Church st. | Oak st. | State st. | | | | | 1455 |
| Water st. | Main st. | Franklin st. | | | | 1510 | |
| Water st. | Franklin st. | Washington st. | | | | | 1075 |
| Franklin st. | Main st. | Water st. | | | 1445 | | |
| Hancock st. | Main st. | Dean st. | | | | | 1570 |
| Mt. Desert st. | Main st. | Pine st. | | | 382 | | |
| Mt. Desert st. | Pine st. | Washington st. | | | | | 2370 |
| Pine st. | Franklin st. | Mt. Desert st. | | | 1430 | | |
| Spruce st. | Hancock st. | Mt. Desert st. | | | | | 820 |
| Gross st. | Franklin st. | Hancock st. | | | | | 230 |
| Grant st. | Main st. | Liberty st. | | | | | 555 |
| Chapel st. | Liberty st. | Court st. | | | | | 920 |
| Pleasant st. | Liberty st. | Court st. | | | | | 915 |
| Liberty st. | Grant st. | Pleasant st. | | | | | 680 |
| Court st. | Main st. | Grant Place. | | | | | 1740 |
| Cross st. | Main st. | Court st. | | | | | 308 |
| Union st. | Main st. | Oak st. | | | | | 500 |
| Summer st. | Grant st. | Chapel st. | | | | | 610 |
| South st. | Main st. | Grove st. | | | | | 1030 |
| Central st. | State st. | Sterling st. | | | | | 930 |
| Sterling st. | Main Pipe. | Central st. | | | | | 480 |
| Shore Road. | Main Pipe. | State st. | | | | 1400 | |
| Washington st. | Water st. | Mt. Desert st. | | | | | 1760 |
| Birch ave. | School st. | Oak st. | | | | | 780 |
| Oak st. | Birch Ave. | State st. | | | | | 1720 |
| Church st. | Oak st. | Union st. | | | | | 770 |
| Total of Distributing | | System. | | 1868 | 6267 | 9565 | 21218 |
| Main Pipe | Branch Pond. | State st. | 25072 | | | | |
| Total | | Amount, | 25072 | 1868 | 6267 | 9565 | 21218 |

| | |
|----------------------|----------------------------------|
| Distributing System, | 38918 Lineal Feet or 7 37 Miles. |
| Main Conduit, | 25072 " " 4 75 " |
| Total Pipe Required, | 63990 " " 12 12 " |

APPROXIMATE ESTIMATE OF COST.

Owing to the great diversity of pressure, I have, for closer approximation of the tonnage, classified and computed the amount of pipe required under each separate head.

| HEAD IN FEET | LINEAL FEET OF PIPE. | | | | |
|--------------------|----------------------|------------|------------|------------|------------|
| | 12 inch. | 10 inch. | 8 inch. | 6 inch. | 4 inch. |
| No. of Ft. | No. of Ft. | No. of Ft. | No. of Ft. | No. of Ft. | No. of Ft. |
| 25 | 3952 | | | | |
| 50 | 4010 | | | | 540 |
| 100 | 6550 | | | 1200 | 3740 |
| 150 | 6860 | | 4122 | 5265 | 11073 |
| 200 | | 1068 | 1445 | 2290 | 4090 |
| 210 | 3700 | | | | |
| 225 | | 800 | 700 | 810 | 1775 |
| Total | 25072 | 1868 | 6267 | 9565 | 21218 |

MAIN CONDUIT.

| SIZE. | No. Lineal Ft. Pipe. | Head in Feet. | Pressure in Lbs. | Thickness of Metal. | Weight per Foot including Bells. | Total Number of Pounds. |
|-----------------|-------------------------|------------------|---------------------|------------------------|-------------------------------------|----------------------------|
| TWELVE INCH. | 3952 | 25 | 10.82 | .4460 | 60 lbs. | 237,120 |
| | 4010 | 50 | 21.65 | .4916 | 64 " | 256,640 |
| | 6550 | 100 | 43.30 | .5276 | 68.8 " | 450,640 |
| | 6860 | 150 | 64.85 | .5636 | 73.7 " | 505,582 |
| | 3700 | 210 | 90.96 | .5996 | 81 " | 299,700 |
| | 25072 | | | | | 1,749,682 |

DISTRIBUTION PIPES.

| | | | | | | |
|--------------|------|-----|-------|-------|-----------|----------|
| TEN INCH. | 1068 | 200 | 86.63 | .5490 | 60.2 lbs. | 64,294. |
| | 800 | 225 | 97.46 | .5690 | 62 " | 49,600. |
| | 1868 | | | | | 113,894. |

| | | | | | | |
|----------------|------|-----|-------|-------|-----------|----------|
| EIGHT INCH. | 4122 | 150 | 64.85 | .4744 | 41.8 lbs. | 172,299. |
| | 1445 | 200 | 86.63 | .4984 | 44 " | 63,580. |
| | 700 | 225 | 97.46 | .5104 | 45.2 " | 31,640. |
| | 6267 | | | | | 267,519. |

| | | | | | | |
|--------------|------|-----|-------|-------|-----------|---------|
| SIX INCH. | 1200 | 100 | 43.30 | .4118 | 27.5 lbs. | 33,000 |
| | 5265 | 150 | 64.85 | .4298 | 28.7 " | 151,105 |
| | 2290 | 200 | 86.63 | .4478 | 30 " | 68,700 |
| | 810 | 225 | 97.46 | .4568 | 30.8 " | 24,948 |
| | 9565 | | | | | 277,753 |

| | | | | | | |
|---------------|-------|-----|-------|-------|-----------|---------|
| FOUR INCH. | 540 | 50 | 21.65 | .3612 | 16.4 lbs. | 8,856 |
| | 3740 | 100 | 43.30 | .3732 | 17 " | 63,580 |
| | 11073 | 150 | 64.85 | .3852 | 17.6 " | 194,885 |
| | 4090 | 200 | 86.63 | .3972 | 18.1 " | 74,029 |
| | 1775 | 225 | 97.46 | .4032 | 18.5 " | 32,837 |
| | 21218 | | | | | 374,187 |

| | | | | | |
|---------|-----------------------|----|---|---|-----------|
| 25,072. | Feet of 12 inch Pipe, | | | | 1,749,682 |
| 1,868. | " | 10 | " | " | 113,894 |
| 6,267. | " | 8 | " | " | 267,519 |
| 9,565. | " | 6 | " | " | 277,753 |
| 21,218. | " | 4 | " | " | 374,187 |
| 63,990. | | | | | 2,783,035 |

2,783,035 lbs: equal to 1242.4 gross tons of cast-iron pipe.
 124 stop gates.
 70 two-way fire hydrants.

| | | | |
|-------------------------------------|------------------------------------|------------|--------------------|
| 1242.4 | Tons pipe, | at \$31.50 | \$39,135 60 |
| 50 | " special castings, | 58. | 2,900 00 |
| 4 | Twelve inch stop-gates, | 56. | 224 00 |
| 8 | Ten " " | 50. | 400 00 |
| 20 | Eight " " | 30. | 600 00 |
| 23 | Six " " | 20. | 460 00 |
| 69 | Four " " | 14. | 966 00 |
| 70 | Two-way fire hydrants, | 33. | 2,310 00 |
| | Trenching, laying and backfilling, | | 31,995 00 |
| | Gate-house and screens, | | 600 00 |
| | Cribwell and filter, | | 400 00 |
| | | | <u>\$79,990 60</u> |
| Add ten per cent. for contingencies | | | 7,999 06 |
| Total cost | | | <u>\$87,989 66</u> |

Respectfully Submitted.

H. A. HANCOX, C. E.

Hudson, Mass., Oct. 9th, 1884.