12

REPORT

OF THE

CONSULTING PHYSICIANS OF THE CITY OF BOSTON

IN RELATION TO THE

ACTION OF COCHITUATE WATER

UPON

MINERAL SUBSTANCES.

BOSTON:
1848.
EASTBURN'S PRESS.

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CONSULTING PHYSICIANS OF THE CITY OF BOSTON

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Boston. City council. Joint standing
Committee on water

WITH DOCUMENTS ACCOMPANYING.

BOSTON:
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CITY OF BOSTON.

THE Joint Standing Committee on Water would call the attention of the City Council to the communication made to them by the Water Commissioners, herewith submitted.

The rapid progress of the work renders it probable that the Water of Lake Cochituate will be delivered in the City within twelve months. The convenience of the inhabitants and the pecuniary interests of the City render it expedient that it should at once come into as general use as possible. It is therefore important that the attention of the citizens should be called to the subject, and that they should be informed as to the best modes of introducing the same into their houses, and the material of which the pipes should be made. The Committee, therefore, submit the following orders.

For the Committee,

JOSIAH QUINCY, JR., *Chairman.*

n, November 2d, 1847.

ed, That the Board of Consulting Physicians ested to give their opinion as to the material of pipes for conveying water from the mains into e houses should be composed, so far as the same ect the purity of the water and the health of ens.

Ordered, That the Board of Water Commissioners be requested to give their opinion as to the best and most economical mode of introducing water into private houses, in pipes of such material as the Consulting Physicians may recommend.

In Common Council, Nov. 4, 1847.

Passed.

Sent up for concurrence.

BENJAMIN SEAVER, *President.*

In the Board of Aldermen, Nov. 8, 1847.

Read and concurred.

JOSIAH QUINCY, Jr., *Mayor.*

A true copy.

Attest, S. F. McCLEARY, *City Clerk.*

TO JOSIAH QUINCY, JR., ESQ.,
Mayor of the City of Boston.

DEAR SIR:

IN compliance with the vote of the City Government requesting the Board of Consulting Physicians to Report, what in their opinion was the best material for pipes to distribute the Water of the Cochituate Aqueduct to the houses of the citizens of Boston, the Board have obtained all the information in their power, and the result I have now the honor to send you in their Report, together with the Documents they have obtained relating to the subject.

I have the honor to be,

Respectfully,

Your obedient servant,

JOHN C. WARREN, *Chairman.*

Boston, April 12, 1848.

REPORT

Of the Board of Consulting Physicians of the City of Boston.

The Board of Consulting Physicians of the City of Boston, having been desired to give an opinion as to the material of which pipes for conveying water from the mains into private houses should be composed, so far as the same may affect the purity of the water and the health of the citizens; have had the subject under careful consideration, and submit the following Report.

It is desirable that the materials of which the pipes of aqueducts are made, should be cheap, of competent strength and durability, easy of application, and free from the liability to communicate any noxious property to the water contained in them. It is to the last of these considerations that the Board of Physicians have devoted their attention, as falling within their particular province.

Of the various *organic* products which have been employed to convey water, *Wood* is the primitive material resorted to in most countries, until superseded by more appropriate substances. *Leather* made into hollow trunks, or *hose*, is used on ship board, and in connection with fire engines. *India rubber* applied in the form of varnish to tubes made of fibrous textures, is employed in certain hydraulic machines. *Gutta percha*, a newly imported substance, has qualities which seem to render it suitable for the conveyance of water. The three first mentioned substances are considered un-

exceptionable on the score of safety, and to the last, no objection on the same ground is known to the undersigned.

Of brittle and inflexible mineral substances, *soapstone* and *marble*, also *glass* and *burnt clay* glazed with siliceous earth, are not injurious to health.

Iron. Pipes and trunks made of cast iron are the most common material used for the conveyance of large bodies of water, and constitute the mains of the Cochituate aqueduct. Smaller pipes, both of cast and wrought iron, have been used for distribution in the interior of houses. The advantage of this metal over others, consists in its entire safety as far as health is concerned. Its disadvantages are, that it is somewhat difficult to adjust, and still more so to repair when broken or separated; also, that it is easy of oxidation, impairs the purity of the water, and in small pipes is liable to obstruction from the accumulation of its oxide. Nevertheless, in some situations, wrought iron pipes have been found to answer well for periods of five years and upwards.

It is proposed by Mr. Dexter to line the inside of iron pipes with charred wood, soap-stone, or other safe material, which may diminish or prevent the action of water upon the metal of the pipes. (See Appendix.)

A siliceous glazing, of a well-known appearance, has been for many years applied to the inside of culinary vessels of cast iron, to protect them from the action of water, and other chemical agents. These vessels are now manufactured by Messrs. Savery & Co., of Philadelphia. Experiments appear to be wanting to decide the fitness of this material.

Tin. Tubes made of pure tin are found to be acted on by water. A portion of Cochituate water which had stood two months in pipes made of block tin, exhibited

abundant proofs of the presence of that metal. Tin appears to be less noxious than copper or lead, and the common use of vessels made of tinned iron, for various economical purposes, seems to afford evidence of its general safety. Tin pipes are flexible, fusible, and easy of adjustment and repair.

Copper, in the form of some of its salts, is an active poison. In its metallic state, it is not very ready of solution in water, yet, according to Professor Horsford's experiments, it sensibly affects that of Cochituate Lake. Copper, exposed to the action of air and water, becomes coated with a carbonate, or oxide, which, in a great degree, protects it from farther action. Copper coins and bronze figures, which have been exposed to these agents for two thousand years, are found in good preservation. Copper pipes, thoroughly coated with tin, in the manner suggested by Mr. Hayes in his report, are considered by that gentleman as one of the most eligible materials, both as to durability and safety. From Professor Horsford's observations, it seems probable that the action of water, both upon copper and tin, diminishes gradually during use.

Lead pipes have been in use for the conveyance of water, from the time of the ancients to the present day. The cheapness of this metal, its ductility, flexibility, and the ease with which it is wrought, have caused it to be employed for service pipes more than all the other materials together. Leaden pipes are liable to be corroded by the water of certain wells and springs, and probably also by rain water. But in the water of open lakes and streams, which are comparatively free from saline ingredients, and which contain portions of organic matter, these pipes are durable for a long period. Lead, in aqueducts, has often been suspected of insalubrity, abandoned, re-placed with other materials, and again restored.

The Committee have devoted their especial attention to the subject of this metal, by examining the published authorities, by making extensive inquiries among practical men, and by engaging the attention of learned and able chemists in fresh investigations bearing on the particular case in question. Certain general facts, in regard to lead, seem at present to be admitted, by the common experience of the world. 1. That lead, received into the body, in certain quantities and for a certain time, is liable to produce some alarming complaints, among which are a species of colic, and a species of paralysis. 2. That most of the natural waters, which are introduced through pipes into the cities of this country, and probably of Europe, are capable, under certain circumstances, of dissolving lead. 3. That notwithstanding these general facts, a large portion of the population of Boston, Philadelphia, New York, and London, have for years consumed the water introduced from various sources through leaden pipes, with apparent impunity.

In the hope of obtaining light on these seemingly discrepant facts, the undersigned have caused to be procured specimens of water from the respective aqueducts of the Schuylkill and Croton Rivers, and of Jamaica Pond and Cochituate Lake, which they have submitted to Augustus A. Hayes, Esq., of Lowell, and to Professor Horsford, of Harvard University, with a request that they would put to a suitable test the action of each of these waters upon metallic lead. From the reports of these gentlemen, which are subjoined in the Appendix to this document, it appears that each of these waters dissolves speedily a portion of the lead with which it is in contact. The partial exception of the Fairmount or Schuylkill water seems to be explained by the attendant circumstances.

But an interesting result deducible from Professor Horsford's experiments, is, that the solvent action of these natural waters upon a given surface of lead, diminishes from day to day, and at length wholly disappears. So that it is not improbable that a coating of an insoluble compound, perhaps arising from the action of organic matter upon oxide of lead, is gradually formed, which protects the metallic lead from the farther action of the water. These experiments may explain the cause why so many persons drink the water from leaden pipes without detriment, and why the waters from Jamaica Pond and other aqueducts have so often failed to furnish evidence of the presence of lead, when submitted to the test of chemical experiment.

In connection with the above explanation, it is proper to state, that the undersigned have procured numerous specimens of Jamaica Pond water, drawn from leaden pipes in various parts of the city, in many of which it had stood over night, and in one instance in a pipe one hundred feet long, for more than twenty-four hours. These specimens were submitted to the chemical examination of Professor Horsford, who reports that he finds no lead present in any of them. Dr. C. T. Jackson reports, "I have never found lead in the water of Jamaica Pond, which was drawn through lead pipe, though nearly all the well waters of this city, drawn through such pipes, are charged with lead." Other chemists have arrived at the same result, in regard to the water of Jamaica aqueduct.

In furtherance of their investigation, the undersigned have caused inquiries to be made in more than a hundred families, residing in Washington, Tremont, Pleasant, Warren, Essex, Harrison, Kneeland, Edinburg, Oxford, Beach, Tyler, Hudson, South, Sea, Purchase, Summer, Atkinson, Charles, Cambridge, North Russell,

Lowell, and other streets, who have used the water of Jamaica Pond drawn from leaden pipes, as common drink, for periods of from two to twenty years; and in no instance has any of the specific diseases attributable to lead, been remembered to have existed in these families.

It is by no means certain that minute quantities of lead, even when received into the human body, do occasion the injurious effects which result from larger quantities. In the ordinary conditions of civilized life, very few persons can hope to escape so receiving them. Lead is present in the paint of houses, and in that of buckets and other receptacles of water. It is contained in the solder of tin plate vessels, and in that of water pipes of various metals. It is used to make tight the joints of iron mains in large aqueducts. It helps to form the cheap pewter of which spoons, plates, and other culinary vessels are made. It is present in the glazing of the coarsest pottery, and in the finest flint glass. It affords the lining of tea chests, and often the coloring material of wafers and other common substances. It is carried through life in the bodies of wounded soldiers, and is applied in various forms by surgeons and physicians, to recent wounds and absorbing surfaces. It is also administered internally as a medicine. The continual liability to mechanical attrition or chemical solution which exists in these cases, while it goes far to establish the inactivity of lead in certain minute quantities, should nevertheless put the community on their guard against the reception of larger quantities, through carelessness, of this and of other metals deleterious to health.

In conclusion, the Board of Consulting Physicians beg leave to express, as the opinion derived from the present state of their knowledge on the subject,

1. That pipes, made of cast or wrought iron, may be safely used for the transmission of water, as far as health is concerned.

2. That copper pipes, effectually tinned throughout by reliable workmen, are a safe material for the contemplated transmission of water to dwelling houses in Boston, so long as the internal coating keeps in repair.

3. That although leaden pipes, in certain waters, and under certain circumstances, are known to communicate a highly deleterious quality to their contents, yet in the open waters, from which the large cities, already named, have been supplied through such pipes, no practical evil of a general nature is known to this Board to have resulted from their employment.

4. That when individuals may prefer not to employ, for purposes of food, water which has passed through leaden pipes, they may introduce it into a lower reservoir through pipes of iron, or other safe material, and conduct it from thence for other purposes to different parts of the house, through lead tubes properly guarded by stop-cocks, valves, or other mechanism.

The Board of Consulting Physicians feel furthermore bound to state, that an imperfection necessarily exists in the experience hitherto had upon this important subject, owing to the difference in samples of metal upon which observations have been obtained, and possibly from the different quality of the same waters in different seasons of the year.

Their investigations, also, have brought them to the belief, that notwithstanding the attention which has been paid to the action of water upon certain metals, in different parts of the world, yet the subject is by no means satisfactorily understood. And they trust that more light may be shed upon it, after the conclusion of a course of observations and experiments now in pro-

cess of being made by Professor Horsford, of the University.

JOHN C. WARREN,
GEO. C. SHATTUCK,
JACOB BIGELOW,
GEO. HAYWARD,
JOHN WARE.

Boston, April 3d, 1848.

In Common Council, April 3, 1848.

Referred to the Committee on Water, with authority to cause the same to be printed.

Sent up for concurrence.

BENJAMIN SEAVER, *President.*

In the Board of Aldermen, April 5, 1848.

Read and concurred.

JOSIAH QUINCY, Jr., *Mayor.*

APPENDIX.

No. I.

Mr. DEXTER'S LETTER.

Boston, Nov. 12, 1847.

Dear Sir:—

In reply to your request, that I would give my opinion as to the best material for conducting water into dwelling-houses, I say that I know of nothing so good as Iron.

It is wholesome, strong, easily obtained, and readily adapted to the purpose. It is, however, practically inconvenient for service pipes. The action of the water causes rust, and a deposit is formed on the iron which gradually closes the pipe, particularly in service pipes, where the water remains for a length of time undisturbed.

To prevent this inconvenience of rust and foreign deposit, a thin lining or coating of charred wood can be introduced into the pipe, and these secured by hydraulic cement, poured, when liquid, between the iron and wood. The cement indurates, and prevents any action of the water on the iron. The charring of the wood prevents any taste being communicated to the water, and also decay is prevented.

I send you a piece of pipe, for inspection, prepared as above. It has been examined by Dr. Hayes, and subjected to chemical tests. He says:—

"The cement used in the space between the wood and iron would prevent any action of the water on the iron, and by converting the wood into brown charcoal by heat, the organic parts, most subject to change, are destroyed, and the basis of the wood rendered indestructible, and *forms a material admirably suited to contact with water.* Water cement, interposed between the surfaces of charred wood and iron, would entirely prevent aqueous action on the latter."

I remain,

Respectfully and truly yours,

G. M. DEXTER.

No. II.

Mr. DARRACOTT'S LETTER.

Doct. J. C. Warren;

Dear Sir:—

Iron pipes cannot be made flexible; they can, however, be bent, and by the use of bends, elbows &c., can be put up in houses for conveying water; but there is an objection to their use which is a bar to it in all cases, unless there is a steady stream always running; namely, the oxidation of the metal. This colors the water, gives it a strong taste of iron, and renders it unfit for washing white clothing.

The two best kinds of pipe are those made from pure block tin, or copper, covered internally and externally with pure tin, in a very thorough manner; these pipes are easily bent, are very strong, and will not change the character of the water in the slightest degree; they will be too expensive for common use, but those who value health above money will use them.

Respectfully your ob't servant,

Nov. 15, 1847. GEO. DARRACOTT.

No. III.

Dr. A. S. HOSACK'S LETTER.

New York, Nov. 16, 1847.

My Dear Sir:—

Since the receipt of your favor of the 11th inst., requesting information respecting the use of lead pipe to convey the Croton water into dwelling-houses in our city, I have made particular inquiry of several of our leading practitioners of medicine, as well as of the agents at the Croton water office, and principal plumbers connected with the same, and also of Dr. Chilton, for instances of the poisonous effects of lead from using the Croton water drawn from leaden tubes. They all, with the exception of Dr. Chilton, assert that they had never heard of any complaints, nor have they ever heard of a single instance of the effects of lead from the use of the Croton water. Dr. Chilton informs me, however, that he had been called upon to analyze water taken from leaden pipes in a house in New York, (which had

been closed for some time previous,) where several persons had been made seriously ill from drinking the same water, and that he had detected the presence of lead in it. He also states that it is his opinion that the effect of lead from drinking of Croton water under such circumstances, is of frequent occurrence, but not recognised as such by the physicians, or rather not attributed by them to the true cause. Dr. Chilton is, as you are doubtless aware, one of our best chemists, and in whom the public have the most unbounded confidence. I enclose you a circular of Mr. Ewbank, upon which, (as it speaks for itself,) I will not trouble you with any comments further than to say that lead pipes are generally in use throughout the city; while those lined and coated with tin are but seldom employed. If you wish any further particulars or certificates from Plumbers, or the head of the Croton water department, I will be most happy to obtain them for you.

With kind regards, etc., I remain very sincerely, your friend,

ALEX. E. HOSACK.

No. IV.

Dr. GRISCOM'S LETTER.

New York, Dec. 14, 1847.

Prof. Webster;

Dear Friend:—

I have delayed a response to your inquiries in relation to the best material for bringing water into houses, and to the effects of lead upon the health of the water drinker, in order to obtain a more full expression of opinion from the members of the profession, as well as from the best plumbers, than I was able to procure immediately.

My own opinion is very decided as to the non-injuriousness of lead pipe as a means of conveying water. I was an attentive listener to the testimony given on this subject some years ago, at a trial in this city, in reference to a patent for tinning pipe; and as far as my recollection serves me, nothing was elicited on that occasion at all convincing that any injurious effects had ever been observed from drinking water that had passed through tubes of pure lead. And it is fair to presume that on such an occasion, when the *utility* of the patent was one of the points in dispute, if any thing could be adduced to prove its necessity, it would have had all possible weight given it. But nothing satisfactory, so far as *facts* went, was discovered.

I have always lived in New York, and have had ample opportunities for observing the influence of the water drank by the inhabitants both before and after the introduction of the Croton. The change from the use of no pipes at all, to the almost universal employment of lead pipe, was, of course, with us very sudden, and it is very reasonable to suppose that if any evil consequences could be attributed to the lead, some case among the 400,000 inhabitants, would have turned up to prove it, within the five or six years that have since elapsed. But not a whisper of the kind have I heard. Thus much for my own experience

To render assurance doubly sure, with regard to the medical experience of this city, I last week laid the subject of your letter before the academy of medicine, the largest professional body we have. At the meeting were several of our oldest and best practitioners. I requested if any gentleman had ever known or heard of any evil results from the use of lead pipe, he would oblige both you and me by communicating the facts. No intimation of such results was offered, as would have been, had any ever been noticed. A negative has been the invariable answer also, from several of our acutest practitioners with whom I have personally conferred.

I have also made inquiries at two of our largest plumbing establishments, as to the popular sentiment on the subject, and the relative amount of tinned and untinned lead pipe called for in their orders. The answer is the same from both; no tin pipe at all is used. In one establishment the opinion was given that the tinning was detrimental to the strength of the lead; that under undue pressure, the pure lead tube will yield a little, but the tin lining, under the same circumstances, will crack and cause the lead to split also, without the expansion. I am unable to say what value there may be in this idea.

From its less flexible character, block tin, which was for a while employed to a small extent as a material for water pipe, has been, I believe, wholly discarded.

Nothing but lead pipe is now used in this city "for the conveyance of water into and within the residences of the citizens."

With great respect,

I am very truly,

JNO. H. GRISCOM.

P. S. There has been frequently observed in pipe which has been removed after use, an internal coating of brown color, which is doubtless the vegetable matter suspended in the Croton, and which is deposited when the water is at rest, and forms a slightly adherent

layer. This interposed between the water and lead would prevent any action of the two upon each other; but before it could occur, the deleterious effects of the leaded water ought, if ever, to be exhibited.

No. V.

Dr. WEBSTER'S LETTER.

Laboratory of the Massachusetts Medical College,
Boston, December 15, 1847.

George C. Shattuck, M. D.

Dear Sir:—

I have now the honor of communicating to you the results of the examination of the water received from you, contained in a stone ware flask and marked "Cochituate Water." The water was quite free from any turbid appearance, and agreeable to the taste.

As you requested me to direct my attention particularly to its action, if any, upon lead, my experiments have been confined to that point.

A piece of new lead pipe was procured, such as is usually employed for the conveyance of water, and such as will be most probably used should the water be distributed in pipes of that material. Should such pipe be used, it will be in contact with solder and the alloy of which the cocks for delivering water are usually made. I therefore deemed it important, to place the water in contact with those materials. Eighteen inches of lead pipe were therefore soldered to one of the common brass cocks (so called). This was filled with the water and placed in a situation, and under the same exposure to light and air, as a pipe of this kind would be ordinarily. After the lapse of eight days the water was taken from the pipe and tested for lead by hydrosulphuric acid. The change of color indicated the presence of that metal.

Fifty grains were taken from another portion of the same lead pipe, weighed with great care, and placed in four ounces of "Cochituate Water" contained in a glass flask. The flask with its contents was placed on a shelf in the Laboratory, protected from dust, or the entrance of foreign matters. This flask was fully exposed to diffused light. At the expiration of eight days the contents were examined. With the same test as in the other case the discoloration was greater. The precipitate obtained, washed and digested in nitric acid diluted with water, was dried and redissolved; with iodide of potassium a

slight yellowness was produced. The iodide of lead thus formed was in too small quantity to be weighed. The shavings of the lead pipe which had been in contact with this portion of water, being dried, were found to have slightly increased in weight.

Fifty grains of the lead pipe were placed in another four ounces of the water, and kept in a perfectly dark closet. At the expiration of eight days, the water was tested. Hydrosulphuric acid immediately produced a very dark color, and on weighing the shavings of lead they were found to have lost very nearly three tenths of a grain. The loss was ascertained not to be wholly owing to solution of the metal or its compounds; about one fourth of a grain of lead was present in the precipitate from the water.

I send you the residual lead, and I think you will perceive a marked difference in the appearance of that which had been kept in the dark from that which had been exposed to light.

I send also, for comparison, shavings of the lead cut from the pipe and exposed merely to the air during the same period of time.

Another portion of the lead pipe was placed in a large jar of the water, covered slightly with a paper, so that the air could have free admission. At the line where the air and water meet, there has been formed a continuous ring of carbonate of protoxide of lead.

From these results, although the quantity of lead which would be taken up by the water with its present constitution, is quite small, I should consider the constant daily use of it if drawn from leaden pipes dangerous. The water is remarkably pure, and, if we are to rely upon high chemical authorities, this increases the probability of its becoming the more impregnated with lead when in contact with extensive surfaces of that metal.

Attempts have been made to protect lead from the action of water by tinning, but I am inclined to think the process has not as yet been brought to that state of perfection which will insure a perfect and continuous coating of tin on the inner surface of lead pipe.

The objections to copper pipes I need not mention. In my opinion iron pipes, and if practicable even tinned, especially in the inside, are to be preferred. They would be still better if glazed on the inside like the iron culinary vessels now so much employed. This glazing resists even strong acids.

A certain degree of flexibility is desirable in the material; if with this we can have resistance to the action of the water and such a state of adhesion of the particles as will not be injuriously affected by heat and cold, we shall have the best material for interior water pipes.

A material with these good qualities, I am encouraged to think, from experiments in which I am engaged, will be found.

With great respect,

I am, my dear sir,

Yours truly,

J. W. WEBSTER.

No. VI.

Dr. HAYES' LETTER.

Lowell, Jan. 6th, 1848.

JOHN C. WARREN, M. D.
Chairman of Board of Consulting Physicians, &c.

DEAR SIR:—

Your note, asking the expression of an opinion, "as to the best material for conducting water into private houses, with a view to its effects on the purity of the water," is received, and it is with pleasure that I reply.

To insure strength to resist considerable pressure, and permanency in the arrangements of pipes for the distribution of the water from the mains, we are restricted to very few materials for this use. Among these, and most generally chosen, are the metals, Lead, Tin, Iron, and Copper. Other materials have been employed in some cases, but for general application, in our climate, and to meet the want of means at present felt, they are inadmissible. Lead, from its abundance, the ease with which it can be worked into pipes, and the mechanical advantages arising from its ductility, has been generally chosen, and its use has greatly extended. Considered in relation to its effects on the purity of the water passing its surface, we enter at once upon a subject of vital importance and interest to those who will use and consume the water which has been contained in pipes made of this metal. It is generally well known, that the compounds which this metal forms with substances contained in natural waters, are poisonous. Physicians are aware that certain forms of disease can be traced directly to the absorption of exceedingly minute quantities of lead compounds daily; the action of the poison being, in some measure, cumulative. Chemists have studied the action of particular waters on lead pipes, and there is not, at the present moment, any want of information on this point, in its scientific bearings. There is, however, an opinion,

originating in high authority, prevailing to some extent, in relation to certain kinds of water, which, from its influence, deserves to be noticed. It has been supposed, from imperfect experiments, that waters containing certain small portions of salts, do not act on lead. Some years have passed since the opinion, favoring such a conclusion, was published. The lapse of that time has permitted the accumulation of facts and observations, which, placing the fallacy of such an opinion beyond doubt, have established the conclusion, that, *all natural waters act on lead chemically, under the varying states of atmospheric changes.* Lead, as a material for pipes, cannot be safely used for conducting water, which is to be used for domestic purposes. The water, from the source of supply, for the city of Boston, has, in a high degree, the power of destroying lead pipes; and even salts, in a crystalized form, have been observed to result from this action.

Tin,—In the form of pipes, resists the action of most waters; its compounds are not so deleterious as those of lead, and it can be easily wrought, but is more expensive than other metals.

Iron,—As existing in the form of cast iron pipes, of larger dimensions than the usual service size, is acted on by river and pond waters; but, excepting in few rare cases, it does not communicate any impurity to the water. The compounds formed adhere to the pipes, gradually diminishing the bore, and finally closing them. This liability to become incrusted, renders the material unfit for the smaller size of pipes. It has been proposed to line the small pipes with cement, charred wood, and soap-stone. I have examined the action of agents on wood-lined pipes;—those with soap-stone linings are preferable. If the junctions can be accurately made, so that the iron surfaces are covered, this kind of pipe seems well adapted for leading the larger quantity of water. In the form of welded wrought iron pipes, the metal is very easily corroded at points; without any uniformity of diminution, holes soon appear, and the pipes become useless.

Copper. As usually seen, this metal is coated by a thin covering of oxide, which is not easily removed by any natural waters. If in connection with other metals, water contained in such pipes acquires a metallic, nauseous taste. The soldered junctions allow chemical action to take place; the water then becomes sensibly contaminated. The "tinned pipes" are often coated with an alloy of tin and lead, the latter metal sometimes predominating. Such pipes rarely impregnate water. Copper pipes, covered with pure tin, the latter metal being alloyed with the copper, constitutes a plated surface. Pipes thus made, have been exposed to most kinds of natural waters under varying circumstances, and in no instance has the water been contam-

inated, or the surface of the pipe corroded. The surfaces of these pipes present a thin covering of pure tin, on an alloy like bronze; one of the most indestructible of metallic compounds. When exposed in wells, under soil and in moist air, these pipes remain wholly unimpaired. Excepting the noble metals, I know of no metallic substance preferable to this, as a material for service pipes. The daily use of water from such pipes for ten years, in addition to observations made in the laboratory, lead me to prefer pipes made by combining pure tin with the surface of copper, for all situations where small pipes are required. They are, even when quite thin, strong enough to resist ordinary pressure; are easily bent and united together. The cost of such pipes, for the volume of water delivered, is less than the cost of lead pipes,—their durability much greater.

In expressing an opinion on a subject of so great importance, I have thought proper to briefly allude to the points which have led to the conclusions formed, making a lengthy reply, without entering into details.

With high respect,

A. A. HAYES.

No. VII.

Dr. HAYES' REPORT.

Observations on the action of some Lake and River Waters on leaden Pipes, containing them.

The samples of water, four in number, were marked Jamaica Pond, Cochituate Lake, Croton River, and Fairmount. Excepting the last, they were clear without being perfectly transparent; slightly tinted by a yellowish brown color. At the temperature of 42° F., they were destitute of odor.

By preserving the samples at from 36° to 40° F., any tendency to decomposition was prevented during the time of the observations.

Two kinds of lead pipes are found in commerce; the one made by the "patent" process, in which heated lead is forced through dies, has its surfaces imperfectly coated with tin. The other cold drawn from thick tube, in general chemical use, better resists corrosion.

From each of these kinds, both new and old, sections were cut; to one end of each piece a strip taken from the same pipe was soldered to form a bottom, so as to allow the pipe to stand vertically. The

solder came into contact with the water, through the same small surface as the ordinary junction of lead pipes would present. In choosing the vertical position, a portion of the water from the surface, or from the lower parts, could be withdrawn for examination, and the great convenience of the insoluble, or sedimentary matter, being collected at the bottom was secured. The pipes were three-fourths inch, one inch, and one and one-fourth inch in diameter; they rested on masonry, kept at a uniform temperature, for each set of observations.

As the pipes when received from the manufacturer have always a film of oil on their surfaces, these pipes were immersed in boiling Merrimack river water till all traces of the oil were removed, and subsequently carefully washed in the water used for filling them.

The observations were made by varying the circumstances of each set; twelve pipes were filled with one kind of water, and exposed to a certain fixed temperature. Their contents were tested from time to time, drawing corresponding quantities from each kind of pipe. By the indication of color, after the addition of the test, the proportion of inpregnation was judged to be greater or less, without regard to statical accuracy. After a number of observations had been made during shorter or longer times, at lower or higher temperatures, the contents of the tubes were removed, and the tubes washed in the kind of water which was next to be used. The observations being finished on the second water, the next set were made on the water first used. This precaution was taken to avoid any error arising from the *state* in which the leaden surface might be left by any sample of water used, and to insure by repetition the greatest accuracy in the results.

The re-agent used for detecting and separating the metal dissolved or suspended, was the pure hydro-sulphate of soda; experience having shown that no known compound of lead resists its decomposing action. The precipitates, or sediments, were reduced to metallic lead, and tested for other metals before the blowpipe flame.

Similar observations were carried on simultaneously with the above. Copper pipes which had been exposed to heated tin until their surfaces were alloyed with it, were used. In some cases the tubes were simply corked, in others soldered junctions were in contact with the water.

(A) Twelve tubes, after being carefully cleaned, were filled with water from Cochituate Lake, and exposed to the temperature of 45° Fahrenheit. Twelve hours after, portions three inches from the surface were withdrawn and tested. In all of the samples lead was found. Portions from nine inches below, gave nearly the same indi-

cations. Twenty-four hours after, the quantity of lead dissolved was increased, and a sediment was found in each tube, composed in part of oxide of lead.

(B) The tubes had been carefully washed and filled with water from Croton river; a repetition of the observations gave nearly the same indications as were obtained with the Cochituate water.

(C) Returning to the water of Cochituate Lake, the same general indications were found. There were some slight differences observed between the samples of leaden pipes and the time; for the same amount of action varied among them, and was not constant for any one sample. An elevation of temperature accelerated the solution of the lead.

(D) On substituting Croton river water, the first observations gave only slight indications of lead, but after the lapse of twenty-four hours, all the tubes contained solutions of lead.

(E) Jamaica pond water was next used in the clean tubes; the indications corresponded with those of the Croton river; a repetition confirmed them.

(F) The Fairmount water exhibited in the trials no considerable action on the pipes after some days. Pipes which had contained it, unless carefully cleansed, were not readily acted on by the other waters following. A slight inspection was sufficient to show that the sample was not in its natural state. Besides the organic matter having taken the form of flocks and filaments, there was a perceptible odor resembling that of alcohol.

(G) Observations with the pipes closed, gave positive evidence of the rapid solution of the lead, and there was always an absorption of the air over the water, to the extent of one fourth, or one fifth of its bulk. The experiments on the water at different levels, did not show any special disposition to corrode in distinct portions of the column, and there were just such indications as would result from testing any solution in the act of taking metal. After the lapse of a certain time, in all cases, a cessation of action took place, matter was deposited which contained lead, and a saturnine solution in clear water remained.

The *quantity* of metal dissolved and suspended was several times obtained. Metallic lead, in a globule as large as an ordinary pin-head, was obtained from one quart of Cochituate water, after twenty-four hours' exposure, as a mean result.

(I) The observations with clean, tinned copper pipes, gave only negative results. By every mode of aiding action which suggested itself, these tubes were exposed, and neither the odor, taste, nor compo-

sition of the water was affected. I have observed the same resistance to the agency of various waters, for the lapse of ten years, and consider the last observations, like the first, as a demonstration, that natural waters do not act on, or corrode, the compound metal forming the surface of such pipes.

The general results obtained, show that the corrosive action of the waters of Cochituate Lake, Jamaica Pond, and Croton River, is not prevented by the low temperature of 45° F., or the temperature of ordinary wells. At the higher temperature of 75° F., the action is more rapidly produced, and the water contains both soluble and slightly soluble compounds of lead.

Presence of air has also a marked influence: the air being excluded until a portion of water had become contaminated with lead salts, its admission caused a rapid increase in the quantity of slightly soluble lead salts.

Agitation, by causing the solution of more air, increased the rapidity of the action; water in motion would have this effect also, and its solvent action would be rendered more active. Change of composition in the water, from exposure to the temperature of 75° in free air, produced a corresponding change in its relations to the lead surface. The observations on this point were not sufficiently extended, but the changed water, in most cases, acted on the surfaces. Connected with this, is the influence of the ochry deposit, which is derived from the iron mains. It has been shown by several accurate observers, that the presence of the iron oxides increases the power which water has, or confers the new power of dissolving lead. Connection with the iron mains has been supposed to exert a protecting influence through the electrical condition of the lead; such an opinion is not, however, supported by observations, nor is it in accordance with any accurate generalizations. The cause of the solvent power exerted by water is found in its composition and changes.

The river and lake waters of most of the geological formations of New England are quite compound in composition, and differ remarkably from the spring and well waters of the same formations. They are generally colored, of some shade of yellowish brown, the tinting substance being vegetable organic matter, of constantly changing composition. Considered as a contamination of pure water, the actual weight of this substance, as obtained by chemical means, compared with the weight of the pure water, is very minute. But its modifying power cannot thus be measured. At different, generally elevated temperatures, the small proportion of dissolved matter induces such changes, that the chemical relations of the waters to other substances become *new*. By

infiltration, these waters meet with substances capable of withdrawing, by combining with, much of the organic matter. Saline substances, existing in the rocks and soils, are dissolved; even the gaseous parts become changed. Well waters always contain more *weight* of dissolved matter, while the *kind* of matter is different from that of river and lake waters.

Pure water, such as is described by chemists, is a very rare product, of refined and delicate operations, which cannot be exposed to air without obtaining from it sensible contamination. Water, which has been distilled from water which has been previously boiled, is the agent much employed in scientific researches. Water received from the clouds on mountain summits, contains a variety of kinds of organic matter, chiefly exhalations from the land surface, particles suspended in the air, and a profusion of microscopical insects, or their remains; besides, as gaseous constituents, carbonic acid, atmospheric air, and often oxygen gas. Rain water is more impure as we approach the earth's surface. Lake and river waters, being collections from superficial drainage, have added to them salts of the rocky strata and soils, vegetable remains of decompositions going on, the seeds and germs of sub-aqueous vegetation, and a profusion of whole species of animalcules. The most important of these substances, in relation to the subject of aqueous action on leaden surfaces, are the various and changing organic matters, which may be acids, or salts in composition, indifferently.

When the river or lake waters, abounding in colored compounds of organic origin, pass over, or have for beds the rocks and soils of limestone strata, their physical and chemical characters are changed. There is, perhaps, no feature of limestone districts so striking as the clearness and green color of the waters, caused by the rocks having combined with the colored matter. *White* rivers owe their origin to this cause, and, where near tinted streams, exhibit a strong contrast. Although a portion of matter is abstracted from the colored water by limestone strata, another portion derived from the rocks is added to the water. This great natural change, at all times going on, is chosen as an illustration of the action which takes place between water and leaden surfaces. The colored matter in contact with the limestone, or even with the shells of living animals, finds a substance which it can combine with to form an insoluble compound, while another constituent of the water dissolves the rocks or shells into its substance. In this way soils are rendered fertile, and waters which were injurious to vegetation become highly nourishing.

In acting on leaden surfaces, the dissolved oxygen in the water assists in preparing the metal for solution. Air, if present, is absorbed:

the continued corrosion of the metal goes on until the solvent power of the water is exhausted. Some of the compounds are deposited, others remain dissolved.

In the actual state of a system of leaden pipes for distribution, the longest time we can assume, is that which would apply to the portions of pipe connected with the mains, and any pipe thus situated would poison the water flowing. If other pipes were used for delivering the water into cisterns placed within dwellings, the farther distribution for all, excepting culinary purposes, might be effected by leaden pipes.

The great importance of any step connected with the noble enterprise of introducing one of the first necessaries of life—characteristic alike of the projectors and the age—has induced caution in conducting the trials; and whatever may be the public decision, the facts thus ascertained must remain.

With the highest respect,

AUGUSTUS A. HAYES, M. D.

State Assayer.

No. XVIII.

PROFESSOR HORSFORD'S FIRST REPORT.

Cambridgeport, March 9, 1848.

DR. JACOB BIGELOW;

DEAR SIR:—

In compliance with your request, I hereby furnish such results of the experiments I have made to determine whether leaden pipes may be safely employed in distributing the Cochituate water, as may aid in deciding some of the questions pressing upon the water Commissioners.

The results of experiments now in progress, and the results as a whole, will be presented to you when my investigation shall be closed. From the labors thus far it appears,

1. That all the waters submitted for examination act upon pure lead, effecting its solution.

2. That the Jamaica water acts most promptly and energetically, Cochituate next, Croton still less, and Fairmount least.

3. That the difference between the action of Cochituate and Croton water, and also between that of Croton and Fairmount, is small; while the difference between these individually and Jamaica is very

great; in round numbers, more than ten to one against the Jamaica. The above remarks apply to the first twenty-four hours' action of the water.

4. With each succeeding day the action is less, and in a few days, ceases altogether with the Cochituate, Croton and Fairmount, and nearly or quite so with the Jamaica.

The following numbers give the average results of several experiments made to ascertain, 1st, the relative action of the several waters upon bright leaden bars; and 2d, the relative action on successive days, — the waters being replaced each succeeding morning with fresh supplies.

	1st day.	*2d.*	*3d.*	*4th.*
Cochituate, - - -	5,20	0,50	0,00	0,00
Croton, - - -	2,20	0,50	0,00	0,00
Fairmount, - - -	0,80	0,50	0,00	0,00
Jamaica, - - -	85,00	3,00	0,05	0,00

The volume of water and surface of lead were the same in each — a half gill to five square inches. In the above table the whole numbers express ten thousandths of a gramme; 100 of these equal about fifteen hundredths of a grain.

The method of estimating these quantities, and the various experiments instituted to secure a reply to each practical question, will be presented in detail in my final account of the investigation.

5. A pint of Cochituate water that had been standing two and a half months in leaden pipe, was evaporated to the volume of a quarter of a gill, and its lead determined. It contained fifteen hundredths of a grain.

It is probable that the action in the tube terminated, as in the case of the bars, in the experiments mentioned above, in the course of a few days, the pipe having become coated with a compound of lead insoluble in, and impervious to, the action of the water.

6. A gallon of Croton water which had been standing thirty-six hours in a leaden tube supplying the fourth story of a building in John street, New York, was evaporated in a silver bowl to the volume of a half gill. In this state of concentration I could detect no lead, though it is possible distinctly to precipitate the one hundredth of a grain from a gill of water.

A section of Croton pipe, that had been used a year and a half, presents on the inner surface a blue coating quite identical with that which a bright lead bar takes on in the course of three or four days' exposure to Croton or Cochituate water. In the former case, where the lead had been exposed a year and a half, the coating is not per-

ceptibly thicker than in the latter case where it had been exposed only a few days.

The examination of Fairmount, Troy, and Albany waters, recently drawn from pipes in use after standing twenty-four hours, is not concluded, nor are my labors, as already intimated, with the Cochituate, Croton, and Jamaica waters; still,

7. Enough has been done to enable me to say with confidence in relation to Cochituate water, that the lead dissolved in one hundred feet of half-inch pipe, in twenty-four hours, the water remaining at rest, will be less than a grain. The pipe being exhausted at the close of the first day and refilled, the lead dissolved on the second day will be very much less. This being repeated for several days, the water will cease to act upon the lead altogether.

The use of a larger pipe will be attended with the solution of less lead, as the surface exposed to the action of an equal quantity of water will be relatively less than in the smaller pipe.

Should any especial use of these results be required before the investigation shall be brought to a close, I suggest that when the plumbers' labors are terminated, the pipes be filled from the reservoir, and remain closed for twenty-four hours, then drawn off and again filled, and this repeated for three successive days; and that during the fortnight following these three days, the water first drawn in the morning, a gallon from the lesser pipes, and two gallons from the larger, be thrown away.

I am, very respectfully and faithfully, yours,

EBEN. N. HORSFORD.

No. IX.

PROFESSOR HORSFORD'S SECOND REPORT.

Cambridge, March 30, 1848.

DR. BIGELOW;

DEAR SIR:—

In compliance with your request of yesterday, I transmit herewith further results of my labors to ascertain what material may best be employed for the distribution of Cochituate water from the street mains.

In my former communication, I gave the average results of a series of experiments with bars of lead of known extent of surface, suspended by fine thread in waters of known volume. The whole number of experiments made upon lead with different waters, is more than two hundred.

The conclusions to which they have conducted me, are,

1. That Jamaica, Cochituate, Croton and Fairmount waters, dissolve lead.

2. That the energy with which these waters dissolve lead, is indicated by the order in which they are mentioned.

3. That the waters being replaced at the conclusion of each twenty-four hours, by fresh supplies, the lead dissolved diminishes with each succeeding day, until the quantity dissolved is inappreciable by a test recognizing lead where only one 100.000th of the weight of the aqueous menstruum is present.

4. That the lead, in process of time, becomes coated with a compound of lead, impervious to the water in which the coat was formed.

The exposure of a part of the lead to the air, while the remainder is immersed,—the contact of the bar with the side of the containing vessel, and the contact of two or more bars of the same metal in the same containing vessel, introduce entirely new conditions, the magnitude of whose influence can only be appreciated by instituting parallel experiments, in which the effects of the several conditions may be compared with each other.

The difference between the experiments which I have made, and those that will occur in the distribution of water in lead pipes, is, that in one case a column of lead is surrounded by water, and in the other, a column of water is surrounded by lead;—the relationship of the two is the same.

I have already mentioned, that 4,000 cubic centimetres of Croton water that had been standing in leaden pipe thirty-six hours, (which pipes had been some months in use,) gave, upon concentration to one two hundredth of its volume, no trace of lead.

2,000 cc. of Troy Reservoir water that had remained twenty-four hours in leaden pipe, several years in use, gave, when concentrated to 20 cc., one hundredth of its volume, no trace of lead.

1,000 cc. of Albany Reservoir water that had been standing an equal length of time in leaden pipe, in use for some years, gave, upon concentration to 20 cc., no trace of lead.

1,000 cc. of Jamaica water,* which had been standing thirty-six

*It will be remembered, that Jamaica water acts more energetically upon lead than any water thus far examined. This is in the absence of connection with the iron mains.

hours in the leaden pipe of the Worcester Railroad Depot, gave, upon concentration to 20 cc., no trace of lead.

Jamaica water, from Nos. 6, 10 and 18 Hudson street, 20 Tyler street, and 800 Washington street, without concentration, gave no indications of lead.

500 cc. of Cambridge hard water, that had been standing twelve hours in leaden pipe in use, gave, upon concontration to 20 cc., no trace of lead.

500 cc. from another locality in Cambridge, similarly treated, gave the same result.

Prof. Booth writes me from Philadelphia, that Schuylkill water, in passing through the leaden supply pipes of that city, a year and a half since, gave no indication of lead. Dr. Hare writes me to the same effect. I have requested Prof. Booth to repeat his examination.

All the waters above mentioned, and distilled waters and rain water, kept in a wooden cistern, act upon lead.

Through how many successive days the action will continue, I have not ascertained.

A letter which I have received from Prof. Graham, of London University, contains the following:—

"The point upon which you desire information is one which has been settled here by long experience. It is, that *lead alone* is used to conduct the water from the street main into houses, or for 'service pipes.' No evil is experienced in London, either from these pipes or the leaden cisterns. Yet, as the latter are filled in general only twice a week, the water must remain in them for several days.

"But if Boston should have the advantage of a constant, instead of an intermitting supply, the cisterns will be unnecessary. The constant supply has lately been considered highly necessary on sanatory grounds; and unless some peculiar difficulty may arise from the greater severity of your winter, the constant supply ought to be insisted upon in the outset."

As copper pipes, and tinned-copper and tinned-lead pipes, have been proposed for distributing from the mains, I have instituted experiments to ascertain if pure tin and copper are acted upon by the several waters in my possession.

The results are, as yet, very incomplete.

Jamaica, Cochituate, Croton, Fairmount, Cambridge hard water, and distilled water, all dissolve copper.

In a series of experiments, continued through eight days, with Cochituate water upon pure copper, (especially prepared for organic analysis,) the comparative results were as follows:—

Days.	*a. Coch.*	*b. Coch.*	*c. Coch.*	*Dis. water.*
1	10.00	3.00	"	10.00
2	lost	3.00	"	2.00
3	5.000	.05	10.00	lost
4	"	"	"	2.00
5	1.00	"	"	0.00
6	1.00	"	5.00	
7	.05	"	2.00	
8	.05	"	.05	

The numbers have the same value as those employed for similar purposes in my former communication.

The results indicate, that with succeeding days the action diminishes.

Cochituate water, that had been standing three months in copper tube, gave no indication of copper with the ordinary reagents. Upon concentrating 150 cc. to 20 cc., and treating with a stream of hydrosulphuric acid, a (comparatively speaking) voluminous precipitate of sulphide of copper took place.

The quantity of copper dissolved by Cochituate water in the first twenty-four hours' exposure, is sufficiently great to be recognized without concentration, where, as in the experiments I have made, the surface of metal is very great, and the quantity of water small: —0.08 M. square, to 20 cc.

With tin my experiments have been still more limited. I find that Cochituate, Croton, and distilled water act apparently more energetically upon tin than Jamaica and Fairmount, in an experiment of two days' duration.

The surface acted upon was small, —0.05 M. square, and the water being but 10 cc., great concentration to aid the reagents was not possible.

The following table exhibits experiments of two days' duration, the water being replaced with fresh supplies, as before mentioned.

		1st two days.	*2d.*	*3d.*
Cochituate, - -	10cc.	0.10	0.02	0.01
Croton, - - -	"	0.01	0.00	0.00
Fairmount, - -	"	0.00	0.00	0.00
Jamaica, - -	"	0.00	0.00	0.00
Distilled water -	"		0.10	0.00

These are rather qualitative than quantitative results, and go to show scarcely more than the sparing solubility of tin in a period of forty-eight hours.

Cochituate water that had been standing two months in block tin pipes gave, without concentration, no evidence of the presence of tin

in solution. Upon reducing 150cc. to 20cc., hydro-sulphuric acid gave a more voluminous precipitate than was given by an equal quantity of water exposed an equal length of time to lead.

The relative quantities, and nearly the absolute quantities of the different metals experimented with above, yielded to Cochituate water in long periods, are expressed in the following table.

542cc.	with	lead	2½	months, gave	0.0055 grammes.
150	"	copper	3	"	0.0265 "
150	"	tin	2	"	0.0055 "

Placing these quantities in a scale of comparison, considering the time as the same, we have,

100cc.	in	copper	giving	0.01767 grammes.
"	"	tin	"	0.00367 "
"	"	lead	"	0.00103 "

That is, equal quantities of Cochituate water in equal times, dissolve copper, tin and lead, in the ratio of 17 : 3 : 1.

These results are from the waters furnished after exposure in them of the above metals, by the Water Commissioners. They are so opposed to our prevailing convictions, that, without further verification, I should fear there might have been some mistake in the materials employed.

In conclusion, it may not be out of place to present an idea of the amount of danger to be apprehended from the use of metallic service pipes.

A gallon of water fills 117 feet of half inch pipe; 75 feet of five eighths pipe; 52 feet of three quarters pipe; and 29 feet of one inch pipe. As not more than fifty feet of pipe will be generally employed, the second gallon drawn will be from the street main in either of the first three sizes, and the third gallon with the last.

Lead becomes covered in a few days with an impervious coat.

Copper is less and less acted upon in successive days.

Tin, in two days, yields an exceedingly small quantity to Cochituate water.

The conditions to which the action of waters upon lead is to be attributed, I am unprepared to state. Experiment will, in process of time, reveal them. The unequal action of different waters, shows that there are conditions upon which solution depends — conditions augmented in some cases, diminished in others, and of course susceptible of elimination by experiment.

Some facts that have fallen under my observation lead me, as others have been led, to ascribe a prominent action to the presence of atmospheric air in the water. I am, very respectfully, yours,

EBEN. N. HORSFORD.

No. X.

PROFESSOR HORSFORD'S THIRD REPORT.

Cambridge, May 2, 1848.

WM. D. COOLIDGE, ESQ.
Secretary of Joint Standing Committee on Water.

DEAR SIR:—

I herewith transmit further results of my labors in relation to the Cochituate water question.

A letter from Prof. Booth, of Philadelphia, received since the date of my second letter to Dr. Bigelow, states that he evaporated one hundred ounces of Fairmount water that had been standing thirty-six hours in leaden pipe, a year and a half in use, to the space of a half ounce, without being able to detect the slightest trace of lead.

Dr. Dana, of Lowell, has found lead in Croton water drawn through leaden pipes from the street mains, and has in his possession pieces of pipe employed to conduct Croton water, honey-combed from corroding action. These two facts have great significance, and have led to the effort to ascertain whether the cause of the action in these cases was local—an imperfect pipe—or peculiar soil, or some other unknown agency, or general—or the Croton water itself. This important inquiry is in progress of being settled.

Jamaica water drawn at No. 6 Hudson street, from leaden pipe, long in use, in which it had been standing twelve hours, gave upon concentration to one tenth of its bulk, no indication of lead.

The same negative result attended a similar experiment with Jamaica water similarly exposed, drawn from Nos. 10 and 18 of the same street, 10 Tyler street, and 800 Washington street.

Jamaica water from a leaden reservoir, at the foot of Beacon street, to which it had been conducted through leaden pipe, gave when evaporated to one twenty-fifth of its bulk no indication of lead.

Waters from two wells in Cambridge received through leaden pipes have been noticed in a previous communication. Neither of them after twelve hours' action contained appreciable quantities of lead.

Water from a third well in Cambridge, after standing twelve hours in leaden pipe, when concentrated to one sixtieth of its volume, gave no indication of the presence of lead.

From a fourth well, water exposed twelve hours in leaden pipe, already fifteen years in use, gave when evaporated to one thirtieth of its bulk no trace of lead.

Water from a fifth well at nearly the same elevation, and not three hundred feet horizontally distant from either of the two just mentioned, that had stood twelve hours in leaden pipe, gave upon concentration to one fourth of its bulk, decided evidence of the presence of lead.

More careful quantitative determination showed about a grain and a half of lead in a gallon, where the water had been standing thirty-six hours in the pipe.

The single distinguishing attribute of this water thus far ascertained, is its possession of Gypsum in solution in large quantity.

My recent experiments upon lead, with the several waters in my possession,* have been directed to secure replies to the following inquiries:

1. Will any elevation of temperature, likely to occur, prevent the formation of the impermeable coat to which reference is made in my former communications? or when formed will such elevation of temperature tend to its removal?

2. Will any quantity of air likely to be present in solution prevent its formation or effect its removal?

3. Will contact with iron prevent its formation or facilitate its solution after having been formed?

To the first inquiry I have secured a negative reply. In various temperatures, ranging from freezing to boiling, the coat has been formed and has not been removed.

With regard to the other two, my results are not numerous enough to warrant the formation of opinions. They are thus far not unfavorable to the use of lead.

My experiments with copper have been continued without interruption with the entire suite of waters in my possession.

Albany and Troy waters scarcely tarnish the copper in weeks; Fairmount acts with but little energy, while the action of all the others is about the same.

This action though feeble is protracted, and explains how the water that had been standing three months in copper tubing, should have contained the large quantity of metal I found in solution.

The experiments, with the entire suite of waters, upon Tin have also been continued. No coat appears upon its surface, and the action does not materially diminish with successive days. This explains how the quantity of Tin accumulated in two months and a half might exceed the lead dissolved in an equal length of time—the action of the water upon lead terminating in the course of a few days.

* Distilled water, Albany and Troy Reservoir waters, Cambridge hard water that coats lead, Cochituate, Croton, Fairmount, and Jamaica waters.

You may be gratified to know the relative amounts of solid residue, and of organic and inorganic matters in the waters with which I have been experimenting.

The quantities are expressed in French grammes, and are derived from 500 cc. of water.

The quantities in the first column are the residues upon evaporation over a water bath; those of the second, express the amount expelled by ignition; those of the third the residues after ignition; those of the fourth are, for the most part, carbonate of lime.

	Residue.	Organic matter.	Inorganic matter.	Insoluble after Ignition.
Distilled water	0.0000	0.0000	0.0000	0.0000 gr.
Albany "	0.0924	0.0198	0.0726	
Cambridge "	0.3918	0.0990	0.2928	0.0676
Cochituate water	0.0267	0.0122	0.0145	0.0050
" "	0.0267	.	.	.
Croton "	0.2175	0.1496	0.0679	.
Fairmount "	0.3007	0.1032	0.1975	0.0239
Jamaica "	0.0268	0.0115	0.0153	0.0070
Troy "	0.0593	0.0181	0.0412	0.0278
Cambridge water that acts on lead.	0.1380	0.0540	0.0840	

I have concluded to postpone the remaining tables containing my results to the final account of the investigation.

It remains to be ascertained in relation to lead—

1st. The susceptibility of this metal to solution when in contact with iron, brass, copper or tin, and both with water. The mains are of iron, the stop cocks will be of brass or copper, and it has been proposed to use lead pipe lined with tin. Experiments to ascertain the effect of contact with iron are in progress.

2d. To ascertain whether the coat that forms upon lead may be removed by any amount of organic matter that can ever be present in Cochituate water, or any amount of air that protracted rains and a low temperature may give to it. Experiments upon the effect of air are in progress.

3d. What will be a proper material for protecting the pipes from external corrosion in soils or mortar, and finally, beside these and other inquiries that are perhaps yet to present themselves as attention is more carefully directed to this subject, there are yet to be established,

4th. Upon what conditions the solution of lead depends, and

5th. Upon what conditions the formation of the impermeable coat depends.

Knowing these it will be easy to foresee whether the variations of seasons will be likely to diminish the safety of employing Cochituate water drawn through leaden service pipes.

The inquiries with regard to the other materials proposed for pipe are less important. Lead possesses such great advantages in its flexibility, the facility with which it may be attached, replaced or repaired, and its cheapness, that, if it can be used with absolute safety, the fact should be known.

Whether it can or cannot be employed for distributing Cochituate water, without possible detriment to health, I earnestly hope, by experiment and observation, to ascertain.

I am very respectfully, yours,

EBEN. N. HORSFORD.

No. XI.

Mr. JERVIS'S LETTER.

New York, April 22, 1848.

To the Board of Water Commissioners of the City of Boston.

GENTLEMEN:

I called on Mr. Chilton, (Chemist,) who early enlisted as the advocate of *tinned* lead pipe — regarding the pure lead as dangerous to health. I inquired if he knew of any cases, in this city, of lead poisoning? He replied that persons had complained to him of being affected by the use of water in lead pipe in this city; or rather, he had attributed to the use of water from lead pipe the effect complained of. On more close inquiry, he said he could not say that such complaints were produced by the use of water from lead pipes, but that they were similar to what would be produced by such cause. He uses the water from an iron pipe. He further stated, there was no doubt that lead was taken up by pure water, and that cases had occurred, where the use of water drawn through lead pipes had been very injurious to health. At the same time, he did not think any perceptible injury would be experienced from the use in passing the short pipe required to lead the water from the street into the dwellings, or such detention as would be likely to occur during the day, in the use by ordinary families using the water from pressure, taking the precaution to let the water run from the pipes after standing over night, or any considerable time.

A trial in the U. S. Courts, as to patent of tinning lead pipe, in this city, was had. On this trial, Prof. Renwick was called as a wit-

ness, and testified decidedly as to the injury of unprotected lead on water, and the necessity of protecting by tinning the lead; — that he would not, on any account, use lead pipe without tinning. On cross-examination — Do you use Croton water? Yes. Ever experience any injury? None whatever. What pipe is used? I presume tinned lead? The plumber who put in the pipe was then called, and testified that the pipe laid was all common lead pipe.

On the same trial, Doct. Lee was called, who testified strongly as to the deleterious effect of lead pipe — that he would not have the water brought into his house, because his landlord refused to put in tinned pipe, and he therefore got his water in the street, from a free hydrant, where he said no lead was used. On cross-examination — Have you experienced any ill effect from using the Croton water from the street hydrant? No. The plumber who put in this hydrant was called, and testified that the pipe used for the hydrant was *pure lead.*

Thus much for learned opinions. I called on Mr. Coffin, who for about five years has been President of the Water Board, and who has been in constant intercourse with water takers. By the mode of doing this business, the application for tapping the pipe is required to be accompanied by the name of the plumber who is to do the work; and this brings the plumbers in frequent contact with the President of the Board. At his office much discussion takes place as to all matters relating to water, and the manner of introducing it into houses; and any complaint as to the injury of lead, would most probably be known to him. Mr. Coffin says he does not recollect to have heard of any complaint that lead pipe had injured any person; and expresses, in most unqualified terms, his belief, that not one well-attested case of injury has occurred in this city, from the use of lead pipe.

I have observed, with much care, the effect of lead pipe in use in my own family; and more especially, as I had from experience known the ill effect of lead on water drawn from a well, some 200 feet; and was much in favor of tinned pipe. From experience I was able to detect the taste of lead, where the water was used some three years, without any apparent injury to the family, who used the precaution of drawing off when it had been allowed to stand any considerable time in the pipe. My observation has led to the conclusion, that with the precaution of running off the water that has stood through the night, or for any considerable time in the pipe, no practical effect, of an injurious nature, will be experienced from the use of lead.

The assertion, "that numerous cases of lead poisoning had occurred" in this city, is believed to be without any well-attested facts to sustain it. Some one must have made a large draft on fancy, to give color to it. One thing is obvious, that in this city, where there was at one time an active discussion on the injurious effect of lead pipe, the subject has become entirely quiet, and the question seems not the least agitated.

Respectfully, your obedient servant,

JOHN B. JERVIS,

Consulting Engineer Boston Water Works.