The Alden Process
of
Preserving & Perfecting
Fruits, Vegetables &c.

ON THE ACTION

OF

WATER ON LEAD PIPES,

AND

THE DISEASES PROCEEDING FROM IT.

BY

HORATIO ADAMS, M. D.,

OF WALTHAM, MASS.

PRESENTED TO THE AMERICAN MEDICAL ASSOCIATION,

AT ITS SESSION OF MAY, 1852.

PHILADELPHIA:
T. K. AND P. G. COLLINS, PRINTERS.
1852.

ON THE ACTION

OF

WATER ON LEAD PIPES,

AND

THE DISEASES PROCEEDING FROM IT.

THE subject referred to your committee embraces two distinct propositions—to wit: 1. The action of water on lead pipes; and, 2. The diseases proceeding from it. A distinct section of the report will be devoted to each of them. The committee will proceed to consider them in the order above designated.

SECTION I.

ON THE ACTION OF WATER ON LEAD.

ON this subject, the committee would report only well-known and well-established facts. Though the chemical action of lead and water is generally supposed to be involved in much obscurity, the well-known facts in this case are sufficient, like well-understood facts in other cases of chemical action, to explain whatever may appear anomalous. The relations of lead and water having been explained, the committee respectfully add such practical remarks as these relations seem to demand.

It may be stated, in the outset, that pure water exerts no effect on pure metallic lead. Pure water is never decomposed by pure lead.

By pure water, the committee understand that which is free from all uncombined oxygen, acids, and alkaline, earthy, and metallic salts. Such water exists not naturally. The effects of natural water in relation to lead are alone to be investigated. The action of natural water on lead is due to foreign matters contained in water. All natural water contains air, acid, gas, and salts. These all exert an effect more or less direct on lead. The salts cause water to be hard

or soft, and these qualities modify the chemical relations of lead and water. The salts in natural water are either neutral or non-neutral; the last are all alkaline. The neutral are, sulphate of lime, common salt, earthy and alkaline nitrates, and chlorides. The alkaline consist of bicarbonates of lime and magnesia, sometimes of bicarbonate of potash and soda.

These several substances act, either singly or combined, on lead. Single action is generally direct, combined action is always indirect. Hence the foreign matters in water may be divided into direct and indirect agents. The first class comprises oxygen, chlorine, and compounds of sulphur and hydrogen.

The second class comprises the alkaline, earthy, and metallic salts, and organic or inorganic acids. Among the foreign matters, oxygen exerts perhaps the most important influence in determining the action of lead and water; when absent from water, action will rarely occur; its action is primary. With the exception of chlorine and hydrosulphurous compounds, no other agents act primarily, and direct action always precedes indirect, primary always precedes secondary action.

Pure metallic lead cannot be put in contact with any direct agent in water without being acted on by it, and the results of this primary action are OXIDES, CHLORIDES, and SULPHUROUS COMPOUNDS OF LEAD.

The degree of oxidation depends on the amount of common air, carbonic acid, and oxidizing agents in the water. If only a small amount of air or free oxygen is present, a compound of two proportions of lead to one of oxygen, or a suboxide, is formed. If carbonic acid and oxidizing agents are more abundant, then a higher degree of oxidation, one portion of lead to one of oxygen, or a protoxide, occurs. All natural water contains oxidizing and decomposing agents, which readily change the lower oxide into a higher oxide of lead; hence it may be said that the result of direct action is the formation of protoxide, chloride, and sulphurous compounds of lead.

Water containing hydrosulphurous compounds is never used for domestic purposes; hence, practically, the only compounds of lead here to be considered are the protoxide and chloride. Bearing these principles in view, it is evident that, since all natural water contains direct or indirect agents, ALL NATURAL WATER ACTS ON LEAD. The result of this primary action is the production of an oxide or chloride of that metal.

The properties of these compounds are highly important. Their mere formation could demand no further investigation, did not their

behaviour towards the water in which they have been produced give that water characters of the utmost importance in its hygienic relations.

Among the most important properties of oxide and chloride of lead is their solubility. Both are soluble in natural water. That oxide of lead is dissolved by pure distilled water, to the extent of about eight grains per gallon, is beyond question. Hence the solvent power of natural water varies in proportion to its purity.

If natural water contained only pure, common air, it would dissolve as much oxide of lead as would distilled water. Hence, in aqueduct service with lead pipe, where natural water flows freely and continuously, oxidation and solution of lead will occur. In this view, it may be said that the purer the water and the greater its aeration, the greater is its action on lead.

On the other hand, natural water aerated contains carbonic acid. This compound, by its behaviour with suboxide of lead, converts that into an oxide, and by its combination with this produces carbonate of lead. This salt, insoluble in pure water, is readily solved by an excess of carbonic acid, or by supercarbonates existing as alkaline or earthy salts. No natural water is so nicely balanced in its relative proportions of absorbed air, oxygen, and carbonic acid, as to form carbonate of lead alone, and hence it may be said that natural water necessarily dissolves a portion of the carbonate of lead which it has formed. Failing of the due proportion of carbonic acid, solution ceases. Failing of air, action ceases.

One may easily understand, then, that, in experimenting in a limited quantity of water, the formation and solution of oxide cease, and hence, apparently, lead becomes insoluble. It is so actually only when retained in *that* portion of water in which it was originally immersed.

Natural water generally contains organic, or sometimes inorganic acids, which convert oxide and carbonate of lead into soluble or insoluble lead salts, while the presence of such acids renders chloride of lead more easily dissolved than by pure water. Mutual reactions occur among the salts of natural water, whence result products of decomposition by which oxide of lead is converted into a salt soluble in water, or its contained salts; the reaction of the per-salts of iron, and of nitrates, is, in this view, of the highest importance. The influence of salts in causing oxide of lead to be dissolved by water is very unequal. Nitrates increase the solubility in a greater degree than do other salts. Sulphates and silicates alone do not dissolve oxide of lead. Viewed singly, the lead solvent power of salts, com-

mon in spring water, is as follows, as determined by Spencer, of Liverpool; the highest being first named:—

Supercarbonate of magnesia.
" " " lime.
Chloride " sodium.
" " magnesium.
" " calcium.

Oxidation of lead and solution of the oxide in water are independent of the degree of hardness; hence the hardness being equal, oxidation may be very unequal. This seems, however, dependent on the quantity present of some particular salts, for a large amount of one salt renders lead soluble, when a smaller amount renders it insoluble. Hence, though the total of hardness may be equal, the solvent power may be very unequal. It may, however, be stated generally that salts causing hardness usually dissolve oxide of lead.

It is easy to determine what is the lead solvent power of each salt. In this question we deal not with single or individual salts. There is an inherent difficulty in determining by experiment what are the effects due to the combination of the various salts in natural water. Analysis may accurately determine the amount of each salt element in water, but the *mode* in which they exist in combination cannot be ascertained. Our arrangement of the union of these elements is arbitrary. It is the *mode* of combination which doubtless influences the solvent power of salts. The weight and solvent power of each salt having been determined, the total solvent power will not be represented by their sum. The *mode* of combination probably varies with the quantity of each salt present in the water; hence every variation in the quantity of any one salt alters the lead solvent power of the water, and gives to the combined salt elements new properties. Hence, it is not improbable that, though analysis may detect the same elements in different waters, and as rigorously as our means of analysis may permit, apparently in the same proportion, yet, a variation in the amount of any one element, too slight to be detected, may influence the *mode* of arrangement of the salts, and the lead solvent power of the water. Temperature exerts also a marked influence on the mode of arrangement.

A *mode* of combination of salt elements of natural water may possibly render that perfectly inactive on lead. It is only on this supposition that such a natural water can be admitted to be found.

But no previous analysis of water for domestic use will allow a prediction as to what its exceptions to the usual relations of lead

and water may be. That can be determined only by actual aqueduct service, continued through a series of seasons, as it is well known that the action of water on lead has been intermitted. Hence, water apparently free from lead to-day may become charged with that metal to-morrow. (See APPENDIX A.)

The actual amount of the lead-solving power of any water is of little moment. It will become important only when it shall have been determined what is the minimum of lead which can exist in water, when used as a beverage, without detriment to health, a question as yet wholly undecided. The committee have yet to learn upon what facts, by what experiments this minimum has been placed by those eminent chemists, Professors Hoffmann, Graham, and Miller (see Report on the Supply of Water to London, *Quarterly Journal of Chemistry*, No. 16), so high as one-fifty-seventh of a grain of lead per imperial gallon of water. "So minute a trace of lead," continue the above-named chemists, "remaining in the water could have no possible influence on the health;" and they seem disposed to adopt, if they do not in fact adopt the opinion of Dr. John Smith, of Aberdeen, "that less than one-twentieth of a grain of lead per gallon produces no deleterious effect on the health of those using it for dietetical purposes."

In numerous cases of well-defined, unmistakable lead disease, which have come under the observation of some of the members of the committee, the water suspected to be the cause of disease has been chemically examined. While, generally, it may be said that the amount of lead in solution would not fall below one-twentieth of a grain per gallon, yet, the cases have not been rare, where disease has been produced by less than one-one-hundredth of a grain of metallic lead per gallon in solution, or one in seven millions of water. One hundredth of a grain of lead is easily detected by a simple stream of sulphuretted hydrogen. Water has sometimes caused disease, under the eye of a part of your committee, where this test showed no trace of lead; yet, lead was abundantly evident after concentration of the water, and the sulphuret thus obtained has been converted into salts of lead, which have been again examined to confirm the hydrosulphurous test. Small as the amount of lead—less than one-seven-millionth of the weight of water—in solution thus appears, the committee are disposed to place it still lower. The Tunbridge well may be adduced, whose water, flowing through a lead pipe, disordered many who drank it; and it contained so minute a trace of lead in solution, that some of the most acute and eminent chemists of the day, men full of chemical tact and laboratory experience, failed to

detect its presence. Happily for the afflicted, lead was at last detected, the pipe was removed, and health returned.

The salts of natural water were at one time thought to be protective against its lead-solvent power. To a limited degree this is true of water holding in solution bicarbonate of lime, a deposit of carbonate of lime gradually incrusting the interior of the pipe. But, as we have no analysis recorded of the water thus flowing through a pipe lime-coated, it is impossible to say whether bicarbonate of lime has ever prevented gradual corrosion of the lead. (See APPENDIX B.)

The doctrine of protective power has been much extended within a few years. It has afforded, and still affords to many minds an argument for the safety of water lead-transmitted. This doctrine has assumed various phases, which may be reduced to the three following:—

1. Protection by certain salts of the "right kind," present in water in a limited proportion, or by salts artificially introduced for the purpose of producing compounds of lead known to be insoluble in pure water. In the latter case, the pipe filled with a solution of the protective salt must be left closed for some months to allow a protective coat to be formed.

This may be called the Edinburgh doctrine, having been promulgated and advocated by Dr. Christison, of that city.

2. Protection by the formation of an insoluble coat of suboxide of lead after a few days, or at most a few weeks contact with water. This may be termed the Boston doctrine. It was there adopted as the ground of safety of using lead service pipes for lake water; fortified as it was by the belief that the inhabitants of other cities, using river or lake water lead-transmitted, had been protected from lead disease by the formation of an insoluble coat.

3. Protection by the presence of a limited amount of carbonic acid present in the water, forming insoluble carbonate of lead.

This is the latest, and it may be termed the London doctrine.

It is assumed by the eminent professors of chemistry named above, as the ground of their belief, that the present distributing lead pipes in London may safely be continued if that metropolis should hereafter be supplied from the newly proposed sources with a constant supply of soft water.

The advocates of protection seem not to have duly considered that their several protective coats, however insoluble in pure water, are decomposable and soluble by the salts contained in natural water. The Edinburgh doctrine has been practically abandoned by its author.

The Boston doctrine has been disproved by the results of analysis of water at present flowing through the lead service pipes earliest laid down by the city authorities. The London doctrine is yet to be proved, but its authors admit that an excess of carbonic acid will dissolve the coat of carbonate, and thus the water will be rendered deleterious if the solved lead exceeds one-twentieth of a grain per gallon.

The whole doctrine of the protective power by the formation of an insoluble, impervious coat on lead by the action of the impurities of water, is set aside by the fact that, however this coat may be formed, lead transmitting water is constantly dissolved. No limit of time has yet set bounds to this action.

This is the lesson of experience taught by the erosion of lead pipes and cisterns. It is the result of experiment that, where no perceptible action is visible, chemical examination detects lead in solution. Without going into details, by adducing evidence on these points, by citing the statements which within a few months have been made to learned associations by scientific men, or to parliamentary committees by practical plumbers, of the ceaseless corrosion of lead by water, the committee would remark, that the doctrine of protection is no longer tenable on scientific or practical grounds. Still it is a doctrine which has many advocates, and exerts an influence on many minds, which is much to be deplored viewed as a question of public hygiene.

This influence can be destroyed, not by reason, scientific argument, or practical experience of the erosion and destruction of lead pipe, but it will be counteracted—

1. When a substitute for lead of some material which, while it has all the practical working advantages of lead, will be equally *cheap*. It is a question of *price*, which always determines and will determine the preference for lead. This consideration with the many will continue the use of lead, however little faith may be placed in the doctrine of protective coating.

2. This doctrine will gradually be overthrown by the numerous cases of disease occurring where lead-transmitted water is used. These cases will be marked in proportion as the knowledge of lead malady, so much misunderstood, becomes more general and searching.

No argument for the safety of lead-transmitted water, founded on the absence of lead malady, ought to be admitted, which does not add to the non-occurrence of disease the fact that the pipe is not

acted on, and that the water repeatedly, and under all circumstances examined, has never shown the presence of lead. Such pipes and such water are unknown to your committee; and they would, therefore, proceed to lay before the Association the facts they possess which prove the danger in the use of lead for transmitting and containing water, by the diseases which the use of lead-water has caused.

SECTION II.

ON THE DISEASES WHICH PROCEED FROM THE USE OF LEAD-WATER.

This is by far the most important, and most difficult part of the duty assigned to your committee; one which they approach with much diffidence, feeling, as they do, their inability to do justice to a subject so fraught with evil to their fellow-beings as they conceive this to be; one, too, which, for its elucidation, requires a more thorough research than the limited opportunities of observation falling to their lot have enabled them to bestow upon it. They will, however, lay before the Association such facts as they have been able to collect, feeling that they have but just entered upon a subject which they hope those who have a wider field of observation may, ere long, more fully develop.

Science has not probably yet revealed all the diseases which proceed from lead taken into the human system. Several serious diseases, however, at the present time, are well understood to have their origin in the absorption of this poison, while others, scarcely less severe and distressing in their character, have not as yet been definitely proved to be thus produced, although many of them have fallen under strong suspicions of having a saturnine origin. Several of these, as some forms of dyspepsia, neuralgia, and rheumatism, from their well-known resemblance to other forms of lead disease, have been so classed by many very intelligent and observing physicians.

The earlier writers considered lead colic as the only form of disease produced directly from the introduction of lead into the system. All other forms of lead disease were considered by them as subordinate to, or consequent upon, this. Their descriptions of even this were often vague and indefinite. Later authors have given more accurate descriptions of *saturnine colic*, and some of the characteristics of several of the other forms of lead disease; but even they considered all these as dependent upon colic. And nowhere among

their writings do we find them well and distinctly described. In short, the pathological conditions of the system under which they were developed, were evidently not understood.

Tanquerel, a quite recent French writer, whose work on this subject should be in every physician's library, was the first to present to the public the true pathology of these diseases. After a patient and accurate research of eight years, at the Hospital of Charity, where nearly all the lead-diseased workmen in Paris and its environs resort for relief, and where every facility for the examination of the patients of this vast establishment was freely extended to him, Tanquerel laid before the public the result of his researches. His examinations were made on a class of patients contracting disease in the numerous lead manufactories in and about Paris. The poison was introduced into the system by the absorption of the numerous inhaled particles of lead which are constantly floating in the atmosphere of those vast establishments, or from particles swallowed in the drink, food, &c., of the workmen. He classes lead diseases, so far as he has observed them, under four distinct and well-determined forms, viz., colic, arthralgia, paralysis, and encephalopathy.

These affections, he considers, have an independent existence, and have no real or necessary relation except their common origin.

That lead, taken into the system in continued small doses, becomes a cause of disease, is a fact too well established at the present day to require notice. Chemical analysis has pointed out one source of this evil, which, till recently, has been, if not overlooked, not properly appreciated, viz., the use of leaden conduits for water for domestic purposes. Yet many well-informed physicians, even at the present day, are not roused to a sense of its dangers, and probably will not be, until the frequency of disease caused by it, attended often by a fatal termination, but still oftener by loss of muscular power, which renders life almost a burden, has spoken in tones too loud to be passed unheeded, and under circumstances too afflictive to be longer resisted.

Lead introduced into the system, from whatever source, may manifest its presence in various ways, before any of the usual forms of disease ultimately produced by it become apparent. These manifestations Tanquerel calls "*primary effects of lead.*" And according as the person is more or less exposed, or imbibes a greater or less quantity of it, will these "primary effects" become more or less strongly developed.

These premonitory symptoms are rarely all produced in any one

individual; yet when a person has been exposed, for instance, to an atmosphere highly charged with lead, or has been drinking water impregnated with it for any great length of time, most of these effects will become apparent; showing that the system is highly charged with lead. On the contrary, where a person less susceptible is exposed to the same influences, or a person of the same susceptibility is exposed to milder influences, these manifestations will be developed only after a longer exposure, and often then in a much milder degree. The presence of these primary manifestations will often enable the physician to decide on a correct diagnosis, when, without them, he may be left in doubt as to the cause and character of the disease before him. They are common to all lead diseases, and generally enter largely into the physiognomy of each of them.

The first of these premonitory symptoms which we shall notice is, the *discoloration of the teeth and gums*. This is generally the first to show itself, and is the one most certain to follow the application of lead in any form to the mucous membrane of the mouth. Says Tanquerel, "The first and most frequent symptom of the presence of lead in the system is a very peculiar discoloration of the gums and teeth. That portion of the gums nearest the teeth, to the extent of one or two lines, generally assumes a bluish or slate gray colour. The rest of the gums often presents a very light bluish-red colour, which insensibly disappears in the rosy tints of the mucous membrane which covers the other portions of the mouth. Sometimes the slate colour tints the whole extent of the gums, and even spreads to the entire mucous membrane of the mouth."

In a majority of cases, that portion of gums nearest the teeth, to the extent of one or two lines, will be found the only part showing the blue slate colour—this discoloured portion of the gums is in time absorbed, leaving the edges very blunt, and the necks of the teeth denuded; which portion of the teeth assumes a decidedly brownish colour, contrasting strongly with the natural yellow or greenish tint of the crown.

This colouring matter is the *sulphuret of lead*, and is formed by a change of chemical affinities; when food, which always contains more or less sulphur, is masticated, some portions of it adhere to the roots of the teeth. A species of decomposition very soon takes place, and sulphuretted hydrogen is formed, which at once combines with any particles of lead that may be taken into the mouth, and forms sulphuret of lead, which is deposited on the gums and teeth precisely where the sulphuretted hydrogen was evolved.

(See *Tanquerel, Primary Effect of Lead.*)

The next most frequent manifestation of lead is the *lead taste, breath, and odour.* Those who have been long exposed to the influence of lead often complain of a sugary, styptic, and astringent taste. The breath has also a peculiar fetid odour, which it is not easy to describe, but which can never be confounded with any other, by one who has ever been obliged to experience its effects; it is as marked as the mercurial breath, but is unlike it, and may be called the "lead breath."

The sense of smell is often affected; persons who have been much exposed to the influences of lead soon experience a smell of metallic lead; they seem sometimes to smell their own breath.

Another premonitory symptom of lead disease is what has been called *lead jaundice.* "When lead jaundice," says Tanquerel, "exists in the greatest degree, the skin is of a foul, earthy, yellow tint; if the disease is less severe, it appears of a pale, slightly ash yellow. This colour appears more decidedly in the face than elsewhere, though the skin of the body and limbs is also discoloured, but in a less degree. This pale yellow, generally united with a very marked bluish discoloration, may be observed very decidedly in the white of the eye. The urine is of a dull yellow colour. Nitric acid does not show that play of colours indicated by Berzelius as a proof of the presence of bile. The excrements are of a very decided fawn yellow colour. The serum of the blood presents a slight yellow reflection, but the yellow colour has no tinge of green."—Page 21.

The discoloration of the skin in lead diseases is not from the absorption of bile. The liver performs its functions as usual, as is shown by the absence of bile in the urine, and its presence, in the usual amount, in the excrements. It is produced by the presence of lead in the system, precisely in the same way that nitrate of silver produces a change of colour in the skin, when used internally for any great length of time.

Lead emaciation very soon follows the jaundiced appearance just noticed, and, like it, does not show itself till the system is highly charged with the poison. "This emaciation, though general, is at first most strongly marked in the face, which becomes wrinkled, and presents the expression of premature old age. These wrinkles give an expression of sadness to some faces." (Tanquerel.)

The pulse is generally soft, small, and compressible, and the beats are rather diminished than increased in frequency.

These primary manifestations of lead are, as has already been stated, common to all the known lead diseases; they are not neces-

sary precursors of either of them, and may not always be found with them, as, for instance, when disease is produced in persons of extreme susceptibility after a short exposure; but their presence, or the presence of either of them, may be considered as a certain indication of the presence of lead in the system, although no marked form of disease may, as yet, have shown itself. They generally occur in the order in which they have been described. The discoloration of the teeth and gums is of much the most frequent occurrence; the next in the order of frequency are the taste, breath, and odour; lead jaundice and emaciation soon follow; the altered pulse will be less frequently observed than either of the others.

It is rare that all these premonitory symptoms are present in any one individual. Should they be so found, lead disease, in some form or other, may be expected soon to follow. On the other hand, any one of them may be present for a long while, before the individual will show any signs of well-marked lead disease.

In the following condensed description of lead diseases, your committee have drawn freely from Tanquerel's elaborate work on that subject. In his descriptions of these diseases, he has left, on most of the leading points, but little to be desired. When practicable, his language has been used, and credit accordingly given.

Lead colic is the most frequent form of lead disease, and is the one most generally known, and perhaps the best understood. The functions of the digestive, urinary, and circulatory organs, are changed by it. It rarely attains immediately its greatest height, yet this may occasionally happen; generally it is preceded by certain morbid phenomena in the cavity of the abdomen. The patient first feels a weight in the epigastrium; dull, fleeting colic pains in the stomach, increased by eating, and sometimes attended by nausea and eructations; appetite diminished or entirely lost; bowels, previously free, soon become restricted; the urine flows with some difficulty, and occasionally with a slight feeling of pain. Patients remain tormented with these comparatively slight abdominal disturbances for several weeks, sometimes months, when suddenly the pain acquires more intensity, and returns at shorter intervals, and soon the disease becomes completely developed.

Pain is the first and most distressing symptom of lead colic. It is generally situated about the umbilicus; sometimes it occupies the epigastrium, but rarely the hypochondria or the iliac fossæ. "These regions seem only to be the centres from which the flashes of pain radiate to other parts of the abdomen."

This colic pain is generally marked by a twisting sensation about the navel; the parietes of the abdomen are retracted, or drawn inwards, which causes the patient to experience a sense of compression, as if a weight was laid upon the abdomen. The pain, at first light and transient, at intervals becomes more severe; the intervals of comparative ease varying from a few minutes' duration to occasionally as many hours. As the attack increases in severity, the patient becomes the victim of the greatest anguish; his whole countenance is disturbed, and he utters the most heart-rending cries, and frightful screams and groans. He becomes restless, constantly changing his position, in the vain hope that the change may give him some relief.

Most of these sufferers rub their bowels or compress them with pillows, cushions, crickets, &c., and sometimes girt themselves firmly with a strap or cord. It would be almost impossible to describe all the various positions these patients assume, or the means to which they often resort for relief, during a severe attack of colic. The severe exacerbations of pain are generally more frequent, and also more violent, by night than by day; it is not unusual to see a patient comparatively easy during the day, when, as the night approaches, he is reminded by the returning pains that the agony of the preceding night is fast gathering upon him.

In mild cases of colic, the pain is not always developed by the same exhibition of suffering. The patient is often able to lie quietly in bed, but generally his countenance, even here, is indicative of more or less distress. The severe pain is almost always relieved by pressure. Constipation generally attends lead colic; sometimes diarrhœa, but this is rare. It is the opinion of Tanquerel that pain always precedes constipation. The patient is often harassed with a kind of tenesmus, or a constant feeling as if he were about to have an evacuation, but his greatest efforts are unavailing, and serve only to fatigue him. Nausea frequently attends colic, and sometimes vomiting; both these accidents are most frequently observed when the pain is seated about the epigastrium; pressure, though it relieves the pain, generally increases the nausea. The tongue is usually moist, with a light coat along the centre extending to the root. It is sometimes swollen. The appetite is always impaired, and if food be taken, it always aggravates the distress. There is also considerable thirst, and drinking freely often relieves, but sometimes increases the suffering. The urinary and genital organs are often considerably affected. If the attack is severe, the urine will be scant, and micturition more or less painful. The testicles of the

male, and the uterus and vagina of the female are often the seat of severe pain.

Respiration is rarely perfectly tranquil; it is usually accelerated during the continuance of a paroxysm of pain, but as the pain is relieved, the respiratory movements soon resume their normal frequency. The voice is often somewhat husky and stifled.

The pulse, at the commencement of the attack, is generally slower than in health; but as the disease advances, or if purgative medicines have been freely administered, it becomes more frequent, and is often intermittent. "This increased frequency of the pulse," says Tanquerel, "must not be mistaken for febrile action; fever does not exist in lead colic, unless it be complicated with some other disease. In simple colic, the temperature of the skin is not affected."

The countenance, in lead colic, is changed. In the face there are strong muscular contractions, indicating great acuteness of suffering; it is impossible to describe the hurried changes of expression which crowd upon each other in rapid succession; yet, once seen, this peculiar and ever-changing physiognomy can never be mistaken; it seems, of itself, almost sufficient to denote the disease.

Such are the phenomena attendant on lead colic. It can hardly be expected that all these manifestations of the disease will be present in any one case; but a sufficient number of them, together with the premonitory symptoms before described, will generally be found to enable the physician to form a correct diagnosis.

As to the seat and nature of lead colic, pathological anatomy has revealed no lesion to which all the phenomena it presents can be referred. It is certainly characterized by functional derangement of all the organs to which the great sympathetic nerve is distributed; but, as no organic lesion is known to exist in these organs, and from the resemblance of the symptoms to neuralgia of other parts, we are naturally led to the conclusion that the disease is a neuralgia of this great nervous centre.

Tanquerel supports the same view, and says: "Lead colic is a neuralgia of the great sympathetic nerve; and according as such or such nervous plexus becomes a kind of centre for the lead excitability, whence lines of irritation radiate, such and such forms of colic appear; thus, as the cœliac, mesenteric, hypogastric, or renal plexus is the seat of neuralgia, epigastric, umbilical, hypogastric, or renal colic will be manifested."

This, we are aware, is assuming that the great ganglionary system is the source of both feeling and motion in the abdominal organs.

Most modern authors, as Andral, Grissolle, Ranque, and others, support this view, both as it regards the functions of this nerve, and also, that lead colic is a neuralgia of this great nervous centre. Bichat, also, in speaking of certain colics, essentially nervous, and independent of any affection of either of the coats of the intestines, says: "These colics are evidently seated in the nerves of the semilunar ganglions. They are real neuralgias of the nervous system of organic life."

There is, probably, no disease which has, from time to time, been treated with a greater variety of therapeutic agents than lead colic —almost every form of treatment has had its advocates, and produced its cures. Our limits will only permit us to give them this passing notice. We must confine our remarks to the modes of treatment which experience has proved to be most successful in the removal and prevention of the disease under consideration.

The first thing to be done, in all cases, is the removal of the cause, where it can be ascertained. This is indispensable to a permanent cure. If it be allowed to continue in operation, a relapse may be expected soon to follow any relief which may be obtained, however perfect for a time it may seem to be. Cathartics are most to be relied upon for the removal of lead colic. These, however, may often be materially aided by the occasional use of other remedies, as will be presently noticed. Croton oil, first recommended in the treatment of this disease by Dr. Kinglake, is the form of cathartic usually employed. The best mode of administering it is to add one drop to two teaspoonfuls of castor-oil, with a little lemon juice, or in a tablespoonful of some demulcent drink. We consider the former the most efficacious mode of administration. Should this dose fail to produce evacuations in from four to six hours, it should be repeated, and in three hours after the second dose, if necessary, be followed by an active enema. This course should be continued till free catharsis is produced. "To obtain all the advantageous results," says a distinguished author, "it should be prescribed at least three days in succession, even when the first dose has produced wonders. No fear need be felt of producing inflammation of the intestinal mucous membrane; it has never been known to occur."

When croton oil disagrees with the stomach, other cathartics will be naturally suggested, as castor-oil alone, Seidlitz powders, &c. &c.

At the South and West, physicians usually administer calomel in this disease; they consider the patient as safe when ptyalism is produced. But the experience of your committee leads them to the

conclusion, without denying the power of this remedy, that the cathartic mode of treatment is much the more efficacious, and is much less expensive to the constitution than the treatment by calomel; it also gives relief much sooner, and is free from the distressing annoyance of a sore mouth. Sulphuric lemonade has, with many physicians, been extensively used in the treatment of lead colic. Dr. Gendrin, physician to the Cochin Hospital, has used it perhaps more extensively than any other physician. With him, he says, it has rarely failed to remove the disease in six or seven days. Other physicians have not generally had the same success in the use of this remedy. Some doubt, others even deny altogether, its curative powers. There can be no question, we think, that it has often been successfully used, though it may not have been so speedily efficacious as some other medicines. As a preventive, there can be no possible doubt of its powers.

Supersulphate of alumina and potass (alum) has been recommended, in lead colic, by several distinguished physicians. Kapeler administered it, in demulcent draughts, to the extent of from one to three drachms per day, and asserts that it always cures, however intense the colic.

Dr. Macgibbon, physician to the Charity Hospital, New Orleans, in a communication in the *New Orleans Medical and Surgical Journal*, recommends that half an ounce of alum be dissolved in one pint of lemonade, one-half of which is taken at a time, the remainder in three hours. In this form, he says, it acts as a gentle cathartic, and, without ascribing to it any specific effects, thinks it may be a very useful addition to the treatment of lead diseases.

The same success has not always attended the use of this remedy by many other physicians. This, like the last-named remedy, forms a part of the chemical treatment, from which so much was at one time expected, on the supposition that there would be a chemical combination formed which would convert any particles of lead in the system into an insoluble sulphate.

The expectations of the advocates of this mode of treatment have certainly not always been realized; yet a degree of success has been attained, which would not warrant us in discarding these remedies as wholly inefficacious either in the cure or prevention of lead diseases. Both may be considered as valuable adjuncts to the course of treatment already recommended.

Recourse has often been had to bleeding, in the severer forms of lead colic; but the general conclusion of most observers is, we be-

lieve, that the disease is not materially shortened by it. If lead colic be complicated with any inflammatory affection of the abdominal organs, bleeding should, of course, be at once resorted to, in order to arrest it; after which, the appropriate treatment for colic should be immediately adopted.

Morphine can be used with great advantage in relieving pain and distress. It is not safe to rely upon it alone for the removal of the disease; but, as a palliative, it is of great value, and often a free dose of it will completely relieve, not only the pain, but that extremely irritable state of the stomach which is so frequent an attendant on this disease, and enable the patient to get a quiet sleep. It also allays the spasmodic contractions of the intestinal canal, and, when judiciously administered, does not appear to retard the operation of cathartics, but, on the contrary, serves sometimes to facilitate their action.

The several anæsthetic agents, as ether and chloroform, will also be found of great value in relieving the extreme suffering attendant on the severe forms of this disease.

The alimentary canal should be kept freely opened, by the daily use of either castor or croton oil for several days, or until all symptoms of colic shall have entirely ceased. Demulcent drinks should be used freely during the treatment. When lead colic is complicated with other diseases, it will become necessary to modify the treatment. If the several complications are of an acute form, they must be subdued before the treatment of colic is commenced, each complication receiving its appropriate treatment. Should the complication be of a chronic character, the treatment for colic should be immediately commenced, avoiding as much as possible that which would tend to increase the chronic malady. Sometimes colic may be complicated with other lead diseases, in which case the treatment might also require some slight modification.

Arthralgia is the next most frequent form of lead disease. "It is characterized by pain in the limbs, without swelling or redness." The pain is constant, but subject to exacerbations; motion generally increases it, but gentle pressure diminishes it. The patient is often seized with severe cramps in the affected parts, on making any motion. There are also great hardness and tension of the muscles in the diseased parts. The pain in the limbs is most frequently seated in the course of the flexor muscles; all parts of the limbs, trunk, and head may, however, at times, become the seat of it; it is often felt in the large articulations, while the smaller articulations of the hands

and feet are rarely affected. The pain is often very sharp, darting, or flashing. During the short intervals of comparative relief which occasionally occur, the patient often complains of a feeling of numbness in the affected parts. The lower extremities are more often the seat of this affection than the upper, and it more often commences in the night than in the day, but is not exclusively limited to either. It is, in short, nothing more than the spasms and cramp pains of lead colic, affecting the limbs instead of the abdomen.

Pathological anatomy has developed no organic alterations characteristic of this form of disease. The functional alterations which attend it are seated in those organs which derive their sensibility from the nervous spinal system. The exalted sensibility of these parts, then, must be referred to an alteration of the nervous fibres communicating with them; showing that the disease is purely a nervous lesion revealed only by its symptoms.

This disease will almost always yield to the daily use of the warm sulphur bath for the space of one week. The best mode of preparing the bath is to add six ounces of the sulphuret of potash to four pailsful of warm water. The patient should remain in it from half to three-quarters of an hour. Should this fail to remove the disease speedily, recourse should be had at once to the cathartic course recommended in lead colic.

Paralysis is of less frequent occurrence than arthralgia, but is oftener seen than encephalopathy. According to Tanquerel, "the paralysis produced by lead preparations may consist in the loss of motion only, in parts at once enjoying both motion and sensibility. In other cases, on the contrary, the sensibility only of these same parts is affected, and they are rendered unfit to receive impressions from external bodies, the power of motion being unimpaired. The first kind of paralysis is called the paralysis of motion, or simple lead paralysis; and to the second is given the name of anæsthesy." These two kinds of paralysis may be combined, so that the parts affected may have neither motion nor sensibility.

Lead paralysis is generally preceded by a sense of weakness, debility, and numbness in the parts about to be affected by it; the diseased muscles soon lose their contractile power, and are not readily called into action, but when once roused into action, will often suddenly give out under it. The disease rarely attacks suddenly; and is generally partial, occupying only one or more sets of muscles; it is rarely complete, embracing all the muscles of a limb. Except where it is complete, paralysis *always* seizes first on the extensor

muscles of the limbs. This fact we are unable to explain, but it is of very great importance in the diagnosis of the disease. This phenomenon is the opposite of what takes place in arthralgia, where the region of the flexor muscles is the seat of pain. The skin generally has a pale, livid hue, sometimes yellow, earthy, dry, and shrivelled; there is also a marked sensation of coldness in the paralyzed parts.

The paralyzed muscles soon lose their plump and rounded appearance, and rapidly diminish in volume. This is rendered more apparent by the flexor muscles retaining as they do their full and plump appearance.

Paralysis sometimes seizes upon the muscles of the trunk. When the intercostal or abdominal muscles are the seat of disease, their functions, so essential to the maintenance of life, are performed with the utmost difficulty.

There can be no doubt that the nervous influence destined to be transmitted to the paralyzed muscles has from some cause been interrupted. "It is difficult," says Tanquerel, "to point out exactly the seat and nature of a disease when deprived of the light of pathological anatomy. Here, as in all purely nervous diseases which leave no traces in the parts where they had their seat, pathological anatomy shows, at least, that this disease ought not to be attributed to organic lesion. Each muscular fibre possesses the power of contracting by the influence that the nerves transmit to it. The seat of the disease must then be sought for in the nervous system." There can scarcely be a doubt that some part of the spinal nervous centre is altered in lead paralysis; this again is revealed, not by anatomy, but by the symptoms only.

Treatment of Paralysis.—Here, as in other forms of lead disease, the greatest variety of treatment has at different periods been adopted. We shall follow our original plan, and notice only such as experience has proved to be of value.

The *sulphur bath* is frequently employed in paralysis with marked good effect; the temperature should be about milk-warm, and the patient should remain in it from three-fourths of an hour to an hour. This will produce a glow and feeling of general heat. The baths will induce a copious perspiration, a fine cutaneous eruption, attended by a general itching. This state of things will soon exhaust the patient; the baths consequently should never be continued for a long time.

Electro-magnetism is a valuable remedy when properly used. The shocks should be conveyed through the paralyzed muscles only; if passed through the entire limb, it will generally do more harm than

good, exciting the sound more than the diseased muscles. One pole of the battery should be placed at the origin, the other at the insertion of the muscles about to be acted upon. It should be used daily from ten to twenty minutes, according to the ability of the patient to bear it.

Strychnine.—This alkaloid is the most potent remedy we possess for the removal of lead paralysis. It, together with electricity, seems to keep the diseased muscles as it were alive or excited, and prevent that dormant state which soon results in a rapid diminution of their volume. If this artificial life in the muscles can be kept up at intervals for a few months, or till the system is cleansed from the lead introduced into it, we may reasonably expect the disease to be eventually removed.

The best mode of administering it is in the form of pills containing one-twelfth of a grain each. The dose should be one pill, given once a day, increasing each dose by one pill, till a sufficient number be taken to produce a slight spasmodic action in the muscles. This dose (whatever it may be) should be repeated daily. In a few days, the patient will begin to move slightly the diseased muscles. The immediate effects of this remedy are generally very disagreeable to the patient, producing a tension of the muscles, and as this subsides a feeling of exhaustion. Frequently the patient will be very unwilling to proceed with it. Your committee believe, however, if the remedy be judiciously given, and persevered in for months, that the disease will generally yield.*

Encephalopathy, according to Tanquerel, is a distinct form of disease arising from the noxious influence of lead upon the animal economy, which would seem to depend immediately upon some lesion of the brain. It embraces all the various forms of cerebral affections which have been observed to arise from lead poisoning. The same author considers that it requires the absorption of a larger proportion of lead particles to induce this disease than is requisite for the production of colic, arthralgia, or paralysis. He establishes four distinct forms of cerebral affection: 1, delirium; 2, coma; 3, convulsions; and 4, a combination of delirium, coma, and convulsions.

In the first of these forms of disease, delirium is the leading feature; it either assumes the peculiar restless, talkative character of delirium tremens, or the more violent symptoms peculiar to acute

* For the particular effects of strychnine, see the case of J. S. Copley Greene in a subsequent part of this report.

meningitis. Two varieties have been described, viz., quiet delirium and furious delirium. In the former of these, the patient is generally quiet, with his features and eyes immovably fixed, with rather an astonished air; the countenance is sometimes composed and thoughtful; at other times, the eyes are turned upwards, and the whole expression is that of ecstasy; when spoken to, the answers are at first sensible, but soon the ideas rapidly succeed each other without apparent connection. The patient is by turns either gay or sad, loquacious or silent. He will be in a constant state of restlessness, tossing his arms, and throwing off the clothes, and trying to get out of bed. Sometimes he will be affected with a light trembling, chiefly in the arms and face, and experiences a hallucination of sight and hearing which at times greatly harasses him.

In the second variety, the eyes are widely opened, menacing, furious, or haggard; the features are contracted; the patient cries, shouts, swears, tears his garments to pieces, bursts through the restraints by which he was confined, and, in short, is in a state of complete and raging insanity. The delirium is sometimes accompanied by spasmodic contractions of the muscles of the face, distortion of the eyes, chattering of the jaws, twitching of the tendons, or tremors of the limbs. Notwithstanding all this nervous disturbance, by suddenly fixing the attention on some very simple question, a rational answer will occasionally be obtained. The progress of both these varieties of delirium is of inconceivable irregularity, varying from instant to instant, without order; but when it is about to terminate favourably, a long, deep sleep supervenes, at the close of which, a complete change is observed, often an unexpected amelioration.

The second, or comatose form, is characterized by coma, more or less profound. Tanquerel distinguishes two varieties of this form, according as the coma exists simply, or as it is combined with low delirium. In the former variety the patient is immovable, the limbs drawn up, the eyes closed, or half closed; he utters occasionally some heavy groans, turns in his bed, opens his eyes only to close them immediately, and is not easily roused from the comatose state in which he is plunged.

In the latter variety, there is a partial rousing from the comatose state, during which the eyes are opened, and a few unintelligible words are uttered, and a degree of restlessness manifested. "These two varieties of comatose encephalopathy," says Tanquerel, "show themselves alternately or isolated, during all the course of the disease, and observe no order in their appearance or disappearance."

In the convulsive form of this disease, Tanquerel distinguishes five varieties: 1. Partial convulsions, in which the face, or one side, or one or more of the limbs, are agitated by repeated quick shocks; or there may be spasms of longer or shorter duration. These symptoms may coexist with delirium and somnolency, or with cephalalgy, more or less intense. 2. General convulsions. The cerebral disturbance, in this variety, may often be attributed to the violence of the colic or arthralgiac pains. The convulsive shocks extend to the whole body, affecting the face and superior extremities most severely; distinguished from epilepsy by the consciousness being partially retained; patients can often relate, in part, what they have experienced during the fit. Reason generally returns after a quiet sleep. 3. Epilepsy; the most common form in which cerebral disturbance from the deleterious effects of lead evinces itself. The paroxysm lasts from two to thirty minutes, and in no case have any traces of an *aura epileptica* been detected. When the attack is light, the patient suddenly falls, deprived of reason and general sensibility; he does not speak, but sometimes utters groans, and is but lightly convulsed. The more violent attacks are characterized in the following manner: "Immediate loss of reason, the globe of the eye turned up, the head immovable, the face suddenly injected, and, in an instant, the florid red colour changes to the paleness of death. Some convulsive movements pass through the limbs, and the body is stiffened; soon these symptoms acquire a prodigious increase; the hand is clenched, and the thumb turned convulsively within; violent spasmodic shakes agitate the whole body. Respiration is modified by the convulsive state of the muscles of the breast; it becomes short, interrupted, jerking, noisy, and afterwards stertorous; a foaming saliva, often bloody, is thrown out with noise and difficulty." 4. Epileptic convulsions. In this variety, the convulsive contractions are less energetic than in epilepsy; usually, there is no foaming at the mouth, or stertor; the spasms are almost continuous, and may last from one to twenty-four hours. 5. Catalepsy. The appearance of a patient, under this variety, is that of a person in a tranquil sleep; he gives no sign of sensibility or feeling when pinched or even burned, and it is impossible to awake him, or fix his attention. If the fingers, hand, arm, foot, or leg be placed in any position, constrained or easy, they are fixed for some seconds or minutes, then shake a little, and fall upon the bed. This state alternates with one in which there is some restlessness of motion and return of sensation. "After some hours, or entire days of alternations of repose and rest-

lessness, the patient suddenly opens his eyes, feels physical wants, and asks to eat or drink."

In the fourth form of encephalopathy, there is a combination of all the symptoms occurring in the three other forms; it presents the type of the disease. The utmost irregularity prevails in the various combinations. Tanquerel gives the following as the most usual and most regular: "The patient is, at first, taken with delirium, sometimes so light that the physician does not recognize it; at the end of some hours, or one or two days, an attack of epilepsy supervenes, in consequence of which, the patient becomes drowsy for some minutes; then he seems to awake, and talks all day; delirium, tranquil or furious, is then more decided than before the fit of convulsions; the same day, the night following, or the next day, one or more attacks of epilepsy supervene again. After each fit, the drowsiness is more profound and long; it is interrupted only for an instant, by a half waking for some minutes, during which the patient murmurs some words, then sleeps again. If the epileptic fit is renewed often, coma becomes very profound, then death takes place. In the contrary case, the patient seems to wake suddenly from his drowsiness, after some hours, or a day."

The encephalic nervous system seems to be the seat of this disease. All the pathological phenomena belonging to it point to alterations in the encephalon. Pathological anatomy, which has shed so much light on all organic affections, has revealed nothing satisfactory concerning lead encephalopathy. If there are organic changes in the brain, they are too subtile to be appreciated by our senses, even with the aid of the microscope.

Of the treatment of encephalopathy, Tanquerel says: "At present, the best means known, for preventing the fatal termination of encephalopathy, is the expectant method. The physician who witnesses such violent accidents of the brain, with difficulty resists the desire of prescribing some treatment, in hopes that it will do no harm, and may, perhaps, prevent a fatal termination; it is painful for him to fold his arms before the disease, but experience is the greatest of masters; the facts referred to are sufficiently conclusive to persuade every practitioner that the best mode of treatment, to oppose to one of the most formidable diseases to which man is subject—lead encephalopathy—is that pursued at the "Charity" by Rayer; that is, the expectant method, of which diet and diluted drinks form the basis."

In giving this brief description of lead diseases, their seat and nature, together with the modes of treatment which experience has

shown to be most successful, it may, perhaps, be considered that the committee have gone beyond the strict limits of the subject committed to them. Their object has been to lay before the Association the means of comparing at once the cases which will be reported, arising from the use of lead water, with the well-established forms of lead disease.

Under this view, your committee feel that the deviation (if it be considered one) will be excused.

From what has already been stated, it appears that, in the present state of science, all known lead diseases are referable only to alterations in the brain and nervous system; and that pathological anatomy reveals no organic changes whatever that can account for the phenomena of these diseases. Where anatomy fails to demonstrate disease, we are naturally led to the only resource left us to ascertain its seat and nature; viz., observation and reasoning on the symptoms it presents. When we find, then, the functions of any organ altered, without any cadaveric lesion to explain the phenomena observed during life, we are at once led to look for the cause to the source from which these organs derive the power of performing their several functions. Following this course of reasoning, we are directly led to the nervous system and the brain, as the ultimate seat of all lead diseases.

Chemical analysis has given us more positive results than pathological anatomy. It has demonstrated not only the presence of lead naturally in the human system, but that it exists in much larger quantities in persons who die of lead diseases than it does in those who die from any other cause. Lead, in such cases, has been found in undue quantities in all the tissues of the body, and also in the blood itself; consequently, it must pervade every part of the system. Its poisonous effect is manifested in a remarkable degree in the brain and nervous system. This is demonstrated by the functional changes in these parts; as has already been shown, in the derangement of the functions of all the organs to which the great sympathetic nerve is distributed, as in lead colic; by functional alterations of the organs which derive their power of motion and feeling from the spinal nervous system, as in arthralgia and paralysis; also by a disturbed state of the brain in encephalopathy.

Lead diseases induced by drinking lead-transmitted water do not differ in their general character from the same disease produced by other forms of lead exposure. In their course, they are often complicated with each other; for instance, colic is often found in connection with

arthralgia, sometimes with paralysis, and even with encephalopathy. Most of the cases, which will be reported by your Committee, present some of these complications. In fact, it is unusual to find a well-defined case of any form of lead disease unaccompanied by symptoms of some other form of disease, produced by the same poison. The following case is one in point: While it presents most of the phenomena of colic, those of arthralgia and paralysis are displayed in a very marked form.

It occurred in the person of a distinguished scholar and eminent divine, Rev. Dr. Lamson, of Dedham, Mass. The case is reported as drawn up by the patient himself, who, in describing his own feelings, has given an admirable delineation of the extreme suffering, the depressed nervous feelings of a person afflicted with lead disease.

Dr. Stimson, a distinguished physician in Dedham, informs your Committee that, in 1836, water was brought to the village from a spring upwards of half a mile distant, through leaden pipes, and distributed from them, through small service pipes of the same material, to most of the houses in the place. Dr. Stimson further states "that the Rev. Dr. Lamson was the first person who became diseased from drinking the water. It was used in his family both for drinking and culinary purposes. His case was one of the most interesting that occurred, was very insidious, and for a long time baffled the skill of other physicians besides myself. The cause of his severe illness was finally detected by accident. One day, when at his house, his wife asked me to taste their water, said it had a sweetish taste, and brought me a pitcher full that had stood over night. (The aqueduct water was not received at my house.) I observed on its surface a scum of leaden colour, resembling drops of lead; it had decidedly a sweetish taste. I had two bottles of it, one drawn early in the morning, to obtain the water that had remained in the pipes over night, and the other taken some time after, and sent to a chemist to be analyzed; saying, if lead was found in solution, we should no longer be in doubt as to the cause of her husband's illness. The chemist analyzed the water, and found it to contain lead in solution."

Rev. Dr. Lamson, in a letter addressed to the chairman of your Committee, says:—

"My dear Sir: In compliance with your request, I will describe to you, so far as I can now distinctly recall them, the symptoms and history of the disease or diseases under which I suffered, some years ago, from the introduction, as I confidently believe, of lead into the

system, by means of water brought in lead pipes. I cannot, after the lapse of several years, determine the precise point of time when my attention was drawn to the malady which, most insidious in its approach, afterwards developed itself in so strange a manner.

"I am not positive as to any decided traces of a diseased state of the system before the early part of the summer of 1838; though I have an impression that the sensations I am about to describe commenced the preceding summer.

"The first symptoms which I can recall (I now speak of my first attack) are a peculiar uneasiness or moderate pain in the bowels, with a sort of feeling that there was required, or would be some action of them, but no effect of the kind ordinarily followed, or could be induced by a natural effort. Yet there was at that time no violent constipation. This uneasiness, or these sensations, were not constant, but grew in frequency, the pain gradually creeping round to the lumbar region, when it became fixed and constant; by degrees, however, diffusing itself over the system, particularly the lower limbs. I do not recollect any pains in the head. But by the middle or latter part of the summer of 1838 I became greatly debilitated, yet was without fever, the pulse not elevated. An uneasiness or pain in the lumbar region now caused me continual suffering. I had a feeling of great misery; could walk but a few steps without wanting to stop and sit down; and if I did so, it was a great effort to rise again. I had a sense of constant lassitude or weariness, and an indisposition to motion. I was perplexed by the symptoms. The least fatigue—and all motion fatigued me—aggravated the suffering.

"I have now a very vivid recollection of going, with two or three friends, to pass a day or two at Nantasket Beach. This must have been late in July or early in August. We went out in a boat, and I well remember my sufferings as I lay listless in one end of it, trying, by various changes, to put myself in a posture of some ease, which I could not succeed in doing. I remember distinctly the question asked me by one of my companions: 'Are you in pain?' I was scarcely able to get home. We rode from the Beach to Dedham in a carryall. I remember the difficulty I had in supporting myself, holding on, as I could, by different parts of the carriage. As soon as I reached home, I threw myself on a bed, and sent for Dr. Stimson.

"The bowels had now become wholly inactive, and it was, I think, two days, at least, before they could be moved, and then very imperfectly. During this time I was in a most restless state, day and night. There was no sharp pain, but a constant, dull, gnawing pain, more particularly in the lumbar region and bowels, and a tired feeling in all the limbs. I was every moment changing my position, seeking ease, but not, for a moment, finding it. I would get out of bed every little time, and sit in a chair, or attempt to walk the room; but it was all the same. There was no relief to be had. After the bowels had been effectually stirred, I found myself in a degree re-

lieved. From this time, the duties of my pulpit were suspended. I gradually gained, however. I now kept out as much as possible."

In the latter part of August, Dr. Lamson went to the sea-shore, and, about the 20th of September, to Eastport and the Provinces; and subsequently travelled, by easy stages, through the interior of Maine and New Hampshire, reaching home in the autumn. After this he walked, or rode on horseback, a distance of ten to twelve miles every day. Exercise did not now fatigue, but seemed to invigorate him, so that he entered his pulpit and preached on Thanksgiving Day. "This, you will recollect," the Dr. continues, "was in the latter part of November of 1838."

"I went through the next year very well, keeping up my system of out-door exercise so far as my duties allowed. In the latter part of winter, or early in the spring—I think it was winter—I had an attack, mainly in the left side, apparently in the intercostal muscles. From this I recovered in no long time, and went on till late in the spring of 1840. Then, and in the early part of summer, I had a return of the old symptoms described as occurring in 1838; only with this difference, that the development of the disease was much more rapid. I went through the same process of active medicines, injections, &c., before the bowels could be stirred. I became more debilitated than before, the countenance assuming, in a more marked degree, the peculiar earthy yellow described by M. Tanquerel.

"Then came on the pure arthralgic pains. They seemed to be deep, as if in the very bone, and were seated more particularly in the flexor muscles, as the inside of the elbow-joints and the joints of the knees.

"Soon after, that is in July, there commenced a trembling of the fingers, which soon passed into decided paralysis, the paralysis increasing for about three weeks. This paralysis was in the extensor muscles of the fingers, wrist, forearm, and arm of both the upper limbs; the lower limbs, with a slight exception I shall hereafter notice, not being affected. My arms, when left to themselves, hung loose and dangling at my sides, as if turning on a pivot. Using only one at a time, I could elevate them only in a slight degree. I could not get my hand to my chin or mouth.

"But what puzzled me at the time was that there were certain motions which I could perform; for example, placing the palm of one hand against the back of the other, I could get them to my face, the flexor muscles of the hand, which were not paralyzed, being thus brought into action. So, too, I could draw on my boots almost as well as ever, the same muscles acting. If my arms were elevated to a right angle with the body, the palm of the hand being turned downward, the whole hand fell at the wrist, hanging loose as a piece of cloth, and the will had no more power over it. I could not, without help, raise the hand in the least, nor so much as one of my fingers, in the slightest degree. When I took a tumbler to drink, I clasped

it with both hands fully spread, and could so get it to my lips. When I ate, I rested my right arm, below the elbow, on the edge of the table, and grasping the wrist with the left hand, and then bringing my mouth down to within three or four inches of the table, I could get the food to it. The backs of the hands became prominently arched; the fingers, when left to themselves, became bent and half shut, the natural consequence, I suppose, of loss of power in the extensor muscles. The rotatory motion of the arm was entirely lost, a fact to which my attention was directed when they attempted to assist me to put on my coat.

"I tried all I could to exercise the poor lame muscles, but all fatigue, that is, all use of them, seemed to be attended with injury. They had totally lost their contractile power. The abdominal muscles were similarly affected, though not in the same degree. If I had any, it was only a very slight power over them, which gave me great trouble when an action of the bowels was needed, though they could at this time be readily moved by medicine.

"All the while there was more or less of arthralgic pain, more particularly at this period in the inside of the knee-joints.

"The pain seemed to have no connection with the paralysis, and was greater in the parts not paralyzed than in those which were. The intercostal muscles on the left side were now affected; for months I could not sneeze; the moment the process began it was arrested by these muscles. The sensation was a very unpleasant one.

"We were at this time entirely in the dark as to the nature of this disease; my physician seemed perplexed at the very extraordinary character of the symptoms.

"I got down to Nantasket Beach, and passed four weeks there with some slight benefit; that is, I became in a trifling degree less debilitated. I could not but remark at the time that, whenever I left Dedham for a few days, I gained a little strength, but relapsed on my return, an effect which I afterwards ascribed to drinking the water, as I at the time used no other. I recollect asking myself at the time, what could be the cause? Was it the atmosphere of the place? That seemed an insufficient solution of the problem. At this time I had some appetite; I could eat enough, in fact, and in general with a tolerable relish. I had no constant thirst, though I felt thirsty at times, especially in the afternoon, or when unusually fatigued. I had little or no fever, though at one time a highly nervous pulse.

"I have spoken of the loss of the power of motion in certain muscles, or their loss of contractility. The sensibility of the muscles or nerves, with a slight exception, was not impaired, but the reverse. This sensibility became intensely acute. There was a soreness or peculiar tenderness in all my flesh. Sitting in a common wooden chair and leaning back, the parts of the chair seemed to penetrate to the very bones. The exception referred to was a small muscle in the inner part of the left thigh; I never ascertained its name. There was a spot of three or four inches in length, and two

or three in breadth, which had lost its sensibility. There was, at times, a sensation of a peculiar and unpleasant kind at the bottom of my feet, a sort of burning, which I used to relieve, when in bed, by drawing up the covering, and pressing the soles of my feet firmly against the foot board, which produced a cool and agreeable sensation. I had also, at times, a violent pain in the back between the shoulders, rather nearer the right than the left shoulder, which I would relieve by getting on my bed, and lying flat on my back, bringing as much pressure to bear on the part affected as I could. This method mitigated the pain before a long time. In a multitude of ways, I was a great sufferer; but the brain I did not think was affected, and I do not now think that it was. There was no appearance of encephalopathy."

Soon after Dr. Lamson's return from the beach, the latter part of August, he was induced to visit the Sulphur Springs of Virginia. The journey was with great difficulty performed. He remained about two weeks at the White Sulphur, and about the same length of time at the Hot Mineral Springs. Returning by the way of Washington, he reached home after an absence of about six weeks.

To resume the narrative. "About this time I heard some talk of lead as the probable cause of my disease, and attention was directed to the water. It was at this time, or a little before, I think, that Dr. Stimson expressed a conviction, or an opinion, that lead might be, or was, the cause. I did not myself think that it could be so, and, in fact, at first treated the suggestion rather lightly. I remembered to have heard it stated, at the time the pipes were laid, that the water being soft and pure would not act on lead. I had, therefore, rested secure. I did not then know what I afterwards ascertained from reading, that the pure and spring waters were quite as likely as others to act on lead. It happened, however, that about this time a volume, treating of mineral poisons, being mainly an epitome, I think, of Dr. Christison's work, was put into my hands. Some symptoms, which he described as those of lead disease, caused me to pause and reflect. About ten days or a fortnight after this, we heard the result of the first chemical analysis of the water drawn from my branch-pipe. This analysis was made by Prof. Webster, of Cambridge. He found the water decidedly impregnated with lead; enough so, in his opinion, seriously to endanger the health of those who should habitually use it. He found acetate of lead, and, I think, carbonate. A quantity of the water was afterwards sent for analysis to Dr. Hayes, and with the same result.

"At this time I was very slightly improving, as I thought. Still I could not be quite sure that the paralysis was leaving me, or was, in fact, essentially better. I may say that I had yet remaining some little scepticism as to the nature and cause of the malady. But the last vestige of it was soon to be put to flight.

"I received from Paris the two volumes of Tanquerel on diseases

occasioned by lead; the work subsequently so faithfully translated and abridged by my friend Dr. Dana. I fell to reading it with great eagerness, and there I found all my symptoms minutely and accurately described, under the heads of arthralgia and paralysis. I could hardly persuade myself that it was possible for one who had not felt the symptoms himself to describe them with so much minuteness and truth. All mystery now vanished with regard to the nature of the disease. I can never feel more certain of any fact whatever, than I was, and am still, that all my suffering came from the use of water conveyed in lead pipes.

"It was impossible, as it appeared to me, to doubt it. I know the power of incredulity, but there are cases in which incredulity itself must yield. I deem this one of them.

"Still my recovery was exceedingly slow; I could perceive no change from day to day; but from week to week I flattered myself that I could. Electricity was tried, but without any perceptible advantage.

"Time and the open air, in which I kept as much as possible, and nourishing food, seemed to me to do the work. The pains gradually left me, and the muscles became strengthened, and returned to their normal state.

"The arms, which had become greatly emaciated, and the wrists and hands, were the last to be restored. By the 1st of January, 1841, I was able to enter my pulpit, and go through the services. But I had then a very imperfect use of my hands; I could write a little, but my chirography looked like that of a very old man. My pen would jump and go all sorts of ways, and was tremulous. In the course of the winter I improved gradually, but for some years occasionally felt the effects of the disease, particularly in the wrists.

"The above is a simple narration of facts and sensations as they now rise up to my memory. I have many times regretted that I did not write a description of my case at the time. I have done it now, at the request of your Committee, and in the hope of benefiting my fellow-beings. You will excuse the length of my communication, and believe me,

With sentiments of great respect,
Very truly yours,
(Signed) A. LAMSON."

It appears, from the remark on this case by Dr. Stimson, that the patient early presented the peculiar jaundiced appearance, already described as one of the primary effects of lead poisoning. He says, "It occurred in an early stage of the disease, while he was suffering under arthralgic and neuralgic pains. Not only the face, but the entire surface of the body became as yellow as in common jaundice from occlusion of the biliary duct; at the same time, the dejections contained a sufficiency of good yellow bile. This colour was more

marked in the face than on the surface of the body, and had a more dirty, earthy-yellow tint than common jaundice. After it left, the complexion had a pale, dingy, leaden hue, similar to others who had become diseased by the reception of this mineral. Another peculiarity was a paralysis of the abdominal muscles to such a degree that he could make no effort to expel the contents of the bowels; this took place much later; we had, therefore, much difficulty in keeping the bowels open."

"There was another person in Dr. L.'s family who became diseased, and presented symptoms similar to his, but of less severity; a coloured female domestic, who had drank the water for eighteen months. Her symptoms were arthralgic and neuralgic pains about the trunk and extremities, impaired appetite, loss of flesh, with a peculiar anxious and distressed countenance, and constipated bowels; was obliged to leave her place, in consequence of her indisposition; after she left, she soon began to mend, and in a few weeks regained her usual flesh and health."

It appears also, from the Doctor's report, that many other cases occurred similar to the one above; for many of the inhabitants continued to drink the water, although warned that it contained a deadly poison, until they began to feel the evil effects of it, when it was abandoned. Most of the cases recovered after the water was discontinued.

The following cases we give in Dr. Stimson's own language:—

Lead Arthralgia with Paralysis.—"April 18, 1849. I was called to visit a patient in a neighbouring town—a Miss Mayhew, aged about 14 years. The following history of her case I received from her mother and the attending physician. She had been confined to her bed for several weeks with what they supposed to be chronic rheumatism. It came on gradually, without fever, with severe pains in the inside of her upper and lower extremities, more particularly about the inner angle of the elbow and knees; then about the loins and chest. The mother said she had pains all over her; sometimes they appeared more severe in one place, and sometimes in another; but when moved she complained of its hurting her everywhere; that she was very nervous, unwilling to be touched, or have anything done for her; much depressed in spirit, and unwilling to see any one. Nothing she had taken had done her any good; she had continually been growing worse and worse; her appetite was very poor, and she had lost much flesh; and her bowels were constipated from the morphine she had been obliged to take to get any sleep.

"The first thing that attracted my attention, as she lay curled up in the bed, was that specific physiognomy peculiar to persons poisoned

by lead. Skin cool; pulse moderate, soft, and feeble; much emaciation. It was difficult to make a thorough examination, she was so fearful it would put her in pain; for, when still, she said she was comparatively easy. On gently moving the limbs, both upper and lower, I found it was the flexor muscles that caused the pain on motion; the abdomen was small; the muscles were rather firm, not soft and pliable. The fingers of one of the hands were curled up into the palm, and I could not persuade her to move them. She breathed naturally, and I could discover no disease of the heart or lungs. I suspected the disease was caused by lead; that somehow or other it had penetrated the system. I questioned the parents about their water, whether it came through leaden pipes; and was informed that it did. It was brought, they said, some distance to the house for washing, as the water was very soft, and their well-water was hard. They had generally used their well-water for drinking and for culinary purposes; but their well had been out of order the last six or eight months, and the water from the aqueduct had been used constantly during that time for all domestic purposes. This water was frequently used in the family while the well was in order, as it came into the house and was so handy; but oftener they thought for cooking than for drinking. These facts confirmed my diagnosis. I gave my opinion that the disease was lead arthralgia, caused by the aqueduct water, and advised an immediate discontinuance of it.

"*August* 29, 1849. Saw her again; her parents brought her to Dedham; she remained here a week under my care. Her general health had much improved; she had gained in flesh and strength; suffered little or no pain; slept without anodynes; appetite good; and the countenance had recovered its normal expression. The extensor muscles of one of the upper and one of the lower extremities of the same side were paralyzed. When she raised the arm, the hand hung pendulous from the wrist. Pronation or supination could neither be performed; the fingers were still drawn into the palm of the hand; no one of them, nor the thumb, could be moved in the slightest degree; they retained their sensibility. When she walked, she shoved the foot on the floor, not being able to raise the toes, which gave her a peculiar and unsightly gait. I prescribed strychnine in pills, commencing with $\frac{1}{12}$th of a grain, and increasing $\frac{1}{12}$th each dose, till she felt the tetanic shaking; $\frac{4}{12}$ths produced the desired effect. The next day she slightly moved the forefinger. She continued to take $\frac{4}{12}$ths of a grain, every second or third day, for several weeks, with much benefit. I did not see her again till the summer of 1850. She then was quite fleshy, her health good, had entirely recovered the use of her foot, could walk or dance without any perceptible difference in the movement of her limbs. She could rotate the lower arm and hand, and move it in all directions, as well as the other, but could not straighten the fingers; the thumb had also recovered perfectly. She played on the piano, using the knuckles of that hand, instead of the extremities of the fingers, with a facility that surprised me. Whether she will ever be able to use these fingers, time alone must

determine. She could not the last time I heard from her, six months since."

Lead Paralysis with Encephalopathy.—"J. Guild, aged fifty-four, a resident of this village, engaged in mercantile pursuits, of rather feeble constitution; had always been able to attend to his business; had never been severely ill previous to May, 1847, when he was attacked with pleurisy, which terminated in effusion into the left pleura. In about two months, the water was absorbed, and he gradually recovered such a degree of health, that he returned to his business in the latter part of the following July. His system was shattered by his long sickness, and his health never so good afterwards as before. Early in March, 1848, he began to falter, complained of being easily tired, walked feebly, said he had no pain, and could not imagine what ailed him; thought he might have more water in the chest, and wished me to examine him. I did so, by auscultation and percussion, and was satisfied there was no disease about the chest, and could discover none anywhere about him. His pulse was feeble, his appetite failing, and flesh declining; but what caused his indisposition, at that time, I could not divine. A few days after this examination, strabismus supervened; one eye turned in toward the nose, and he could not roll it out; the external muscle of the eye was paralyzed. He could see as distinctly as ever with either eye separately; but, whenever he looked with both, the object appeared double. He continued about his business several weeks after this, much in the same state, though rather declining; he had some slight pains about the chest at times, and was apprehensive his old difficulty would return, and wished me to examine his chest frequently, which I did, but could discover no disease there.

"I advised him to take a journey; he did, to the Sulphur Springs, in New York; he remained absent but a short time, feeling too unwell to be from home. Soon after his return, he complained of numbness in his fingers; it soon increased to such a degree that he was unable to button his clothes; and soon after this, there was evidently paralysis in the extensor muscles of the arm. The countenance began to put on that expression so peculiar in all who suffer from lead disease. I was satisfied that lead had penetrated his system in some way; but how? The aqueduct did not come to his house or store; he believed it unhealthy, and never used it. He had his store painted and grained in the inside; the workmen were a fortnight doing it, in the month of March; he was in the store every day, with the doors and windows closed, while they were about it. The strabismus occurred during this time. Did he inhale the poison of lead in a sufficient quantity to cause the disease? I thought not, as the earlier symptoms appeared some weeks previously. On further inquiry, I learned that the water he drank and used for culinary purposes came from his well through leaden pipes. We had two junk bottles of the water, one from the pump, and the other from the well outside the leaden tube, sent to Dr. Hayes, a distin-

guished chemist, formerly of Roxboro', now in Boston, for analysis. Lead was found in both bottles, but less in No. 2 than in No. 1. How long the leaden pipe had been in the well could not be certainly ascertained; they were sure it must have been in a number of years, probably five or six; no one else of the family had suffered from it. We were now fully satisfied the cause of the disease was discovered.

"The patient was put under the treatment recommended by Tanquerel; viz., sulphurous baths and pills of strychnine. The baths were prepared by putting five ounces of sulphuret of potash to each bath; they were taken six days in succession, then omitted; gr. i of strychnine was made into twelve pills, beginning with one, and increasing one every day, till the tetanic shakings were produced; four pills generally affected him, and caused as severe shakings as he was willing to bear, continuing two or three hours before they entirely ceased. This course was interrupted, then again repeated, as long as it was thought best, without apparent benefit; at any rate, he gradually grew worse, with the exception of the pains about the chest; they were better. The paralysis increased in the extensor muscles of both the upper extremities, and soon after, one of the lower was so severely affected, that he could neither dress nor feed himself, nor walk without assistance. The debility and emaciation increased, also the tremor; the complexion, a pale dirty white, and the physiognomy peculiarly marked. His spirits greatly depressed; if a neighbour called to see him, would burst into tears, and be unable to speak, for some time. This state of mind appeared in all the severe cases; the stoutest hearts seemed to succumb, become passive and non-resistant. Bowels constipated, readily moved by medicine; pulse normal, but feeble.

"He continued with little alteration till early in October, when encephalopathy supervened;* he became delirious during the night, talked incoherently; countenance wild and staring. This continued ten or twelve days; at times, would talk rationally, and answer questions correctly, then wander and be quite insane. After the affection of the brain terminated, his general appearance was much as it had been previously, only more debilitated. He continued from this time gradually to sink, and became very much emaciated before his death, which took place January 2, 1849."

We have selected but two of Dr. Stimson's many cases of the well-marked and well-defined lead diseases, which appeared in Dedham, Massachusetts, a few years since; so common were these diseases, at one period, that they might have been considered in the light almost of an epidemic.

But as soon as the inhabitants were convinced that they were

* The chairman of your Committee first saw this patient, in consultation, on the last day of September, 1848, when he began to show some symptoms of the approach of encephalopathy.

caused by the use of lead water, *most* of them abandoned it, and the great frequency of the disease disappeared.

But some of them were sceptical, and continued to use the aqueduct water, and were unwilling to believe in the poisonous quality of it, until forced to do so by their personal experience in the diseases caused by it.

The Doctor himself, at a subsequent period, suffered a severe attack of arthralgia in his lower extremities, from using water drawn from a well through a lead pipe.

His wife also had an attack of paralysis in the lower extremities, which prevented her from walking; she could not rise from her chair without taking hold of something and pulling herself up; she was also unable to raise her toes from the floor. The disease continued to increase till the cause was discovered and removed; since which the Doctor has had no return of the pain, and his wife has gradually recovered the use of her limbs. His case had some points of peculiarity; the pain always came on in the night, was seated in the inside of his knees and legs, and seemed to him as if it extended to the marrow of the bones, and was always relieved by pressure.

The Committee regret that their limits will not allow them to give the Doctor's minute description of these two cases entire.

The following cases, communicated by letter to your Committee by Dr. Challiss, of Moorestown, Burlington County, New Jersey, will show, that the liability to disease does not always cease immediately on abstaining from the cause. One case of colic occurred two months after the patient ceased to drink the water; and the case of paralysis did not show itself till three months after the use of the water had been discontinued. The first case of colic was also attended by some symptoms of encephalopathy.

"The family of William Clark commenced making domestic use of water, transmitted through lead pipes, on March 20, 1851; with the exception of his son George, who commenced in September, 1850. George, who was a man of robust and plethoric constitution, was taken with colica pictonum, April 3, 1851, and after a severe illness of three weeks, convalescence commenced. Lancinating pain in the bowels and severe cephalalgia were the prominent symptoms. He was at times delirious, very restless, and manifested great concern for his affairs. But, as soon as ptyalism was produced, the severity of the symptoms abated. But, before leaving this case, I would state that, in the September following, he had another attack, and died under the care of a homœopathic physician; the only case, out of five, in this family, that was treated homœopathically, and the only one that died. April 7, 1851, Mrs. Clark, who is old and

anemic, was taken, and did not fully regain her health until June 12, 1851. Her symptoms were, in character, the same as her son's, but not so acute. Susan (the daughter), who is a young woman, of ruddy countenance and full habit, was taken May 3, 1851. She did not remain ill after May 15. The onset of the disease, in this case, was threatening, but the recovery was rapid. The symptoms were, in the main, the same as in the preceding cases.

"William Clark was taken October, 1851, with paralysis of the left arm, but which, in about four weeks after I began the treatment, was restored to use. For the particulars in regard to this case, I would refer you to the January number of the *New Jersey Medical Reporter*, (from which we gather the following facts: 'The appearance of the patient was very much changed from what it was a short time previous. His countenance was pale and sunken, his expression melancholic. That vivacity which was a marked feature of his character was gone, and sadness and silence sat enthroned.')

"He was able to make flexion and extension but to a slight degree; but, what is singular, the grasp was as perfect, and as strong as in health. The condition of the left side was involved in great obscurity. To the touch, that part, extending from the false ribs to the crista ilii, and from the dorsal vertebræ to the left rectus muscle, presented a hard and indurated feel. The hardened mass lay immediately beneath the skin, and could be traced only to the muscular system. His general system was not at all deranged. This attack came on three months after the water, which had poisoned his family, had been discontinued for domestic purposes."

The following cases are extracted from a letter addressed to the Committee by Dr. J. T. Garrison, of Swedesboro', West N. Jersey:—

"In the autumn of 1847, Mr. C. laid a train of one-inch lead pipe from his residence to a spring about a mile distant, for the purpose of conveying the water from it to his house and barns. The spring being on a hill which was more elevated than the buildings for which the supply was intended, no machinery was required to impel the water through the pipes; it made its way along them, by its natural gravitation, into large wooden tanks provided for it in the kitchen and cattle yard. When the spring was very low, as sometimes happened in warm weather, the pipes were but partially filled by the current, room being thus left for the entrance of air into the unoccupied space. I cannot ascertain the exact time at which the water was first used by the family more nearly than that it was in the latter part of the summer, or the first of the autumn; but from this time it was used constantly; and, as it was esteemed peculiarly pure and good, none other was ever employed for culinary purposes or drinking. The cattle and horses were also supplied exclusively from the same source.

"There was no illness in the family during the winter of 1847; nor the spring of 1848, until the middle and latter part of May, when several members of the family began to complain of feelings

of uneasiness in the abdomen, with pains over the body generally, accompanied by constipation in some, and in others by tenesmus and small bloody stools. Mr. C. himself was especially affected, and became gradually worse, suffering from violent colic pains, with unrelenting constipation, until June 20th, 1848, when we were called on to visit him. Dr. Garrison (senior), who first saw the case, found him in excruciating pain, which was located near the umbilicus; it never left him for a moment, and seldom even remitted decidedly; this was attended with intense retraction of the integuments of the abdomen towards the spine, and a hard knotty feeling of the muscles in various places over its surface.

"The bowels had not been moved for five days previous to the visit, although there was a frequent and urgent tenesmus; his pulse was rapid, his skin hot, his countenance anxious, his tongue furred, and his gums fringed along their edges with the strongly marked blue line, said to be pathognomonic of the presence of lead in the system. His stomach was also disordered; so much so as to induce a frequent desire to vomit.

"The peculiarity of the symptoms, joined to a knowledge of the facts above mentioned, respecting the water which he was in the habit of using, left no doubt of the nature of his ailment. He was treated by bleeding and the administration internally of calomel and opium, followed by senna and salts, cream of tartar, and jalap, and other purges, which were, however, one and all rejected; nor was the constipation overcome until the morning of the third day of our attendance, when it was effected by the use of croton oil, assisted by enemata. After this, he gradually improved, and on the tenth day (June 30th) was decidedly convalescing."

"Mrs. C. and several of the children had also been suffering in a similar manner, though not so severely; and, on examination, we found the gums of six others of the family distinctly marked with the blue line along their edges; but, by suspending the use of the water, and some slight medication, they were soon made quite well. Since this time, the family have entirely discontinued the use of this water for cooking and drinking; but the cattle and horses have been allowed to take of it freely, and as yet without any injury to their health that is notable."

A gentleman from New Hampshire called to consult the chairman of your Committee, a few months since; but, being absent, he did not see him. Soon after this gentleman's return home, he sent by a friend a bottle of water to be analyzed, and the following history of his own and his wife's case—two very well defined cases of arthralgia, accompanied by slight paralysis of the muscles of the extremities. It is quite remarkable that he should have noted most of the prominent symptoms of the two diseases above mentioned. The water contained traces of lead, sufficient, in all probability, to produce the state of the system which he describes. They had no suspicion that

lead poison was the cause of their troubles until this was suggested to them by a friend, who had known something of the effects of it in other instances.

We give the letter in his own language, which is eminently descriptive of the diseases from one not familiar with the phraseology of medical science:—

"In 1843, we began to use hard water, drawn through heavy, one and a-half inch lead pipe; in 1851, renewed the pipe, the old being very badly corroded, in fact, eaten through in several places. At the time we began to use the water, Mrs. G. and myself were in good health and spirits; previous to which, neither of us had laboured so hard as we have since; both of us have been troubled, more or less, during the whole period since 1844, with numbness in our hands and arms. Mrs. G. for most of the time has been in good health and spirits, has generally slept well; the exceptions are, the numbness, before mentioned, and more particularly in 1850–51, was much troubled with *lame*, *weak*, and *painful* limbs, particularly in her knees; she is now nearly recovered in this particular; yet she is, from numbness or something akin to it, now frequently unable to write, sew, or knit. We discontinued using the water in August last.

"My own case is substantially as follows: In the first place, I have drank very freely of the water, particularly in warm weather; it is quite cool, and I have indulged copiously in the luxury, and, as a general thing, my health and spirits have been bad; generally worse in autumn, often down or very near it at this season; better in the winter. My back has been lame, weak, and painful; my knees and legs at times nearly useless, or in other words extremely feeble; very troublesome dreams almost nightly; generally restless; on rising in the morning, often (not always) completely enervated, with neither energy, strength, nor courage; depressed exceedingly; stirring about, however, soon, in a degree, remedies the difficulty.

"In 1849–50, I was greatly troubled with pain in my leg; frequently awoke in the night in most intense agony; a sudden jump, with hard rubbing, would very soon cause relief.

"I also had thirty or forty sores, something like boils, on the back of my thigh and above; 'push boils' in the commencement, but they enlarged and discharged very much. My teeth began to work loose and come out before I left Boston; they, however, went rapidly after I came here; the last that were firm, say four or five, the dentist took away in 1849.

"I have described my feelings as nearly as I can; you will bear in mind the *hard work*, and also the ages, being now fifty-four and fifty-six."

The cases which follow fell under the immediate observation of Dr. Dalton, a member of your Committee from Lowell, Mass.:—

The case which I shall first describe strongly illustrates the in-

tractable character of lead affections, so long as the cause remains unsuspected, and in continued operation, and also how liable this is to be overlooked by even the most sagacious members of the profession, in the absence of suspicious circumstances.

"E. M. Read, a mason, 35 years of age, married, of a fine constitution, and in the enjoyment of perfect health, removed from one of the factory boarding-houses (supplied with water, for domestic purposes, through a wooden pump) to a residence on Gorham St., Chapel Hill, in 1836. His health remained good until the early part of 1839, when he began to have attacks of colic, with constipation, attended with a disagreeable sense of heat in the bowels; loss of flesh and colour—his skin assuming a yellowish dingy aspect; pains in his lower limbs, with a sense of weakness, stiffness, and numbness, with frequent, indeed almost daily, attacks of colic. Eructations; loss of appetite, with all the variety of dyspeptic symptoms. Naturally cheerful, his spirits became depressed, and he became very nervous. These symptoms, which came on very insidiously and gradually, in the course of a few months were much aggravated, and from their frequent return, after partially yielding to active cathartics, alteratives, bitters, &c., became alarming.

"The treatment, which relieved in the early stages, failed to be of any benefit as the case advanced. Practitioner after practitioner was consulted, with equally unsatisfactory results. The costiveness became constant, while cathartics and even laxatives aggravated his sufferings; colicky pains recurred almost daily, and he suffered from a sense of stricture, as if a cord were drawn permanently tight around his body at the navel.

"At this juncture, he consulted Dr. James Jackson, and remained a week under his care, in Boston; by him, leeches were applied twice freely to his abdomen, and with immediate, but transient relief; in a few days, the pains, &c., returned, and leeches were ineffectually repeated. Dr. Jackson dissuaded from the further use of medicine, advising him to a strict course of diet, and such as was calculated to produce a soluble state of the bowels, without resort to purgatives. This course was strictly followed, but the disorder remained substantially unaltered.

"No inquiry or reference, up to this time, was made by any one, as to the true cause of the difficulty. Some five or six months previously to his own ill health, the health of his wife and of his only daughter had become impaired; the former suffering from frequent attacks of colic, pain in the limbs, nausea, vomiting, numbness and stiffness of the lower extremities—the latter, from spinal irritation, dyspepsia, fetid breath, and convulsions.*

* In about a year after their removal to Ch. Hill, Mr. R.'s son, a child about two years old, began to be affected with anomalous symptoms in his bowels, terminating, after a few weeks' illness, in fatal disorder of the brain, which, at the *post-mortem* examination, exhibited, however, no tangible traces of disease. The father feels a conviction that the child owes its death to the influence of lead in the water of the house, which, he says, constituted its constant beverage. I did not see the case.

"About this time, similar cases, in this same neighbourhood, had occurred; and several in my own practice. The result was a suspicion as to the true cause; which was at once confirmed by chemical examination of the water in the wells, which was found to be supplied to all the families in that portion of the city through lead pipe, in some cases several hundred feet in length; of course no time was lost in substituting other material for lead in supplying the family of Mr. R.; which example was very soon followed in the case of the other sufferers.

"From this time, Mr. R.'s symptoms began to mitigate; the attacks were less and less severe; and, although his recovery has been slow, he is now in the enjoyment of nearly the same amount of health as when he first removed to the district. His wife and daughter also soon recovered."

Similar cases, of a more or less pronounced character, continued to occur in this, as well as in other parts of our city, all of which were traced to the use of water impregnated with lead; not a small number of them terminating fatally, either before the cause was detected, or from an obstinate incredulity on this subject, which prevented its removal at a sufficiently early stage of the affection to admit of recovery. But, eventually, this incredulity was overcome; lead pipes were generally removed; block tin or iron substituted—and forthwith the intractable character of the disease disappeared; protracted cases began to permanently mend; new ones became less frequent, and finally very rare, occurring only now and then, here and there, where the avarice of a landlord had refused to listen to the voice of humanity, by submitting to the trifling expense required in the exchange of the material above mentioned. When cases did occur, they were at once identified, and the cause being immediately removed, recovery began, and was soon established, with very little, and in some cases with no medication. In one of the cases above alluded to, the water for the uses of the family was brought through a lead pipe more than 400 feet in length; scarcely one of its members, domestics, or visitors, however transient their stay, escaped attacks of disease, bearing evident marks of their saturnine origin; the visitors being attacked with nausea, vomiting, constipation, and colic; the more permanent members with the same as well as with the more severe and dangerous symptoms; yielding but imperfectly to treatment as long as the cause remained undetected, but recovering rapidly and permanently so soon as this was removed. One of these cases terminated in complete paralysis of both lower extremities, which eventually disappeared under the use of strychnine.

Although, as I have above intimated, there were here and there

cases of the affection in other localities within the city, yet by far the larger number, and most severe ones, took place in that portion of Lowell embraced by what is called Chapel Hill; a fact readily explained by its peculiar geological structure, abounding in those chemical agencies which, in their various plays, act with energy upon lead, producing either soluble compounds, or suspending it in indivisibly diffused particles, throughout the water; these, prevailing less abundantly elsewhere, the affections under consideration were less, both in amount and severity. In a very large majority of the cases, the suspected water was subjected to appropriate tests, by competent chemists, principally by Dr. Dana, and invariably found charged, in a greater or less degree, with the noxious principle.

The following letter, from a manuscript lecture of the late Dr. Howe, of Billerica (having allusion to one of the fatal cases which he saw, in consultation with Dr. Bartlett, and which occurred in the Chapel Hill district), may not be without interest:—

"In the year 1836, I owned a house in Lowell; the water supplying it was drawn from the well through lead pipe some forty feet long; my patient was a man of a broken-down constitution—he sickened and died. During his illness, I saw him occasionally in consultation with Dr. Bartlett, his attending physician. The case exhibited some peculiarities; the symptoms were obstinate and unyielding; and from them I was induced to fear that our patient was suffering from the use of the water. Without expressing my apprehensions to the physician or friends, I determined to ascertain whether the water might not be contaminated with lead; *the pump forthwith got out of order, and would not go at all.* I procured privately, through a friend, two junk bottles of water, drawn from the same well, and in the same manner: one bottle contained water which had stood in the pipe over night—this I marked No. 1.

"The other bottle was filled directly fresh from the well—this I marked No. 2. Both bottles were sent to Dr. Jackson (C. T.) to be analyzed, &c.

"In due time, he wrote me that bottle No. 1 contained lead in sufficient quantity to enable him to reduce it to the metallic state; that bottle No. 2 contained some traces of lead, but in much smaller quantity than No. 1.

"We then, without assigning any reason for so doing, immediately removed the pipes from the well, and introduced wooden pumps in their places.

"On the 2d July, 1842, I was called in consultation with Dr. H. of Lowell, to visit a young lad belonging to a respectable family in that place; it was a case of real Devonshire colic, attended with symptoms too clearly defined to be mistaken by any medical practitioner; one other member of the family was suffering at the same

time, but under a milder form of the same disease. The boy died in a day or two after I saw him."

In the following case, although the symptoms were unmistakably those of arthralgia and colic of lead, I was for a long time baffled in my attempts to ascertain the fact, in consequence of my patient's want of good faith towards me; who, either because he had no belief himself in the poisonous qualities of lead, or from a fear of the expense which might be involved in the acknowledgment, concealed from me, not only the important fact that the well water used in his family was drawn through some twenty feet of lead pipe, but also the far more important one, that, about a year previously, he had caused the water from a neighbouring hill to be brought into his tannery through lead pipe, a distance exceeding two thousand feet; which water, in consequence of its "superior freshness, coldness, and *sweetness*," he had been in the habit of drinking when about his work; of course, he was warned against a repetition of his error, and, since his recovery, has enjoyed perfect health, having become himself convinced of the true origin of his complaint.

"H. T., aged forty-five, a tanner; after suffering for several weeks from pains in his limbs, shoulders, neck, face, and head, attended with costiveness and abdominal distress, was seized on Nov. 26, 1850, with violent colic, when I was called to him. I then learned that, for several weeks before the onset of the above train of symptoms, he had loss of flesh and appetite, frequent nausea and occasional vomiting, and the skin had become sallow and dingy. I found the abdominal walls drawn in and perfectly rigid; pulse weak, and but little quickened; little or no feverish action, indeed his skin was rather inclined to be cool. Although naturally patient of suffering, he was importunate, nay, clamorous for relief, uttering himself in terms of agony far stronger than his general appearance and symptoms seemed to warrant; active and frequently repeated cathartics alone afforded him any satisfactory relief, the distress recurring the moment the bowels ceased to be kept in a perfectly soluble state. The effects of opiates were transient; sulphuric acid drinks were freely used, and, after a fortnight (the active symptoms having been subdued), sulph. quinine and other tonics were administered."

In the following case, the patient was but little inclined to acknowledge the habit to which his repeated attacks of the characteristic symptoms were mainly due.

"Alva Eaton, aged forty-four, carpenter, has generally had good health; in 1848, had severe typhoid fever, from which his recovery, though protracted, was perfect.

"In the —— of 18—, he entered the Lowell machine-shop, and continued in the enjoyment of his ordinary health, until the fall of

1851, when he began to suffer from "rheumatism" of the back, hips, and lower extremities; his knees became weak and stiff, making locomotion painful, particularly the going up and down stairs; to these were occasionally added colicky pains, which repeatedly confined him several days at a time, partial recovery following the use of cathartics, sweats, liniments, &c., self-prescribed and administered.

"In August last, an attack of these symptoms, under an aggravated form, attended with rending, twisting pains about the umbilicus, shooting through to the back and down the limbs, and with obstinate constipation, nausea, and vomiting, compelled him to call in medical advice. In my absence, Dr. D. attended him, and, after repeated and long-continued cathartics, the severity of the symptoms gave way, and an imperfect recovery took place in about three weeks. His appetite, however, did not return. Some pain in his bowels, weakness and stiffness of lower extremities, with dull pains in the back of his head, extending upwards from the spine, remained; the true nature of his case having been overlooked, the cause was unsuspected, and of course allowed to continue in operation. He, however, went to work, when, after the lapse of about five weeks, another attack of equal severity with the last took place, with which he was confined about ten days, taking as a cathartic, principally, castor-oil and calomel; the last producing a slight constitutional effect. Getting out, he continued at his work until Jan. 11, when he began again to complain of abdominal pains, and, on the 5th, was seized with all the symptoms marking his previous attacks—yielding, as did the last, and under similar means, in about ten days. As strict inquiry elicited no source of the suspected poison within the family, we were forced to the conclusion that it was derived from the white lead, with which, to prevent rusting, the pieces of iron machinery were smeared, previously to being packed in boxes, to be sent away, it being his principal employment to perform this duty.

"Before he got out from this last attack, however, the much more probable cause was ascertained to be his habit of stopping at a beer-shop, on his way to and from his work, and indulging in potations of that villanous compound, which was drawn through lead pipe. At any rate, he has since abstained from this habit, and has remained, ever since, entirely free from any vestige of his former symptoms."*

The case of which I will now proceed to give a brief account came under my notice recently, and occurred in the persons of two families, occupying a house in the extreme north-western part of our city, quite removed from the locality of those already detailed.

"I was called to Mrs. R. on Friday, Jan. 9th of the present year, and found her labouring under symptoms of approaching abortion, of which, however, she was not aware, inasmuch as (she said) her

* For another case of lead disease, viz., the dropped wrist, which was traced to its causes only after the most thorough inquiry, see Watson's Lectures, Philad. edition, page 811: the case of Mary Ann Davis.

present sufferings were only an aggravation of what she had suffered for many months. She was thirty years old, the mother of one child, and considered herself now advanced about four and a half months; abortion took place in two or three hours; size of fœtus justifying this estimate. She then gave me the following history: Having, previously, always enjoyed good health, in January, 1850, gave birth to her first child—got up well, and continued in good health during the whole period of lactation, weaning her child on the last of Sept., 1851. About the third week in October, began to experience a "tired," heavy feeling of pain in her lower limbs, particularly her knees; the same pain was soon felt about the navel and in the groin, giving the sensation of a cord pulling down, and extending to the very lower part of the bowels; soon a similar pain was felt in the shoulders, back, arm, hands, fingers, feet, and toes, particularly over the tops of the feet and hands. She suffered the characteristic nausea of pregnancy for the first two months, none afterwards, until Dec. 31, when she was seized with vomiting, with an increase of all the symptoms just named, until it closed with abortion.

"Has occupied the same house for a year and a half, and used the water from the well until a fortnight since. After her confinement, the pains in her limbs, &c., disappeared, and at the present time she is quite well.

"Mrs. B. and four adult children, three girls (one married) and one boy, occupied the lower story of the same tenement, where they have lived for four years.

"Mrs. D., the married daughter, aged 23, without children; enjoyed good health until about last October, when she began to have dull, aching, heavy pains in her feet, which gradually extended to her legs and bowels; in December, was seized with severe pain in the stomach, radiating thence to both groins, striking down both limbs, particularly the left; also a dragging pain from the chest, as if a string was stretched from it to the groin; severe nausea and vomiting, with obstinate constipation, nervous restlessness, thirst, coldness of feet, cold chills, frequent desire to pass urine—which was painful; urine often high-coloured, and depositing a lateritious sediment; pains also in the back, hips, and down the spine, extending occasionally up the neck to back part of head; also in hands and feet, and numbness of the same; loss of flesh, with dirty yellowish colour of skin and eye.

"Mrs. D. called for medical advice about Dec. 1, but obtained only partial relief; it being difficult to persuade the family that their illness was caused by the water. This, however, she consented, after a while, to give up; was put upon a course of sulphur and sulph. acid; and, after one or two relapses, began permanently to mend.

"I found her, on the 14th Jan. last, as follows: Pulse 88, soft; skin has a dry feel; tongue slightly coated with white; gums, where they run up between the teeth, bluish, but no regular distinct line; appetite good; sleep quiet; bowels regular; has now occasionally attacks of pain in the bowels and limbs, but, on the whole, is much improved

within the last fortnight. March 19, has now scarcely any remains of former symptoms.

"Thryphena B., sister of the above, has suffered precisely in the same way, but less in degree, commencing about the same time; but, supposing her symptoms owing to long confinement and over-work at her business (factory harness-making), went into the country in Sept. and returned, after a month's absence, relieved of her pains, stiffness of limbs, &c.; but, after a few weeks' residence with her mother, had a return again of all her symptoms—was put under same treatment as her sister, and with similar results, carefully abstaining from the suspected cause. She is now (March 15) quite well. The blue line, at first much more marked than in Mrs. D., still continuing perfectly distinct.

"Amos B., the son, has, within the last two years, had repeated attacks of lead colic pains in both arms; numbness and stiffness of lower limbs, so that frequently he was not aware when they touched the ground; dysuria; blue line well marked, which still continues at this date (March 15), although he has been quite well for two months, and has not used the water since.

"Sarah B., aged seventeen, youngest member of the family, went away to school in June last; similar temperament and constitution with the above; has never had any symptoms, however, of lead disease, and the gums are entirely unstained.

"Mrs. B., the mother, aged fifty-eight, has frequently suffered from arthralgic, colicky pains, and costiveness; blue line marked; has been decidedly in better health, since she omitted the use of the well water, than for several years."

The water, for all domestic purposes, was supplied to both families from the same well, through lead pipe. Dr. Dana, at my request, tested the water, and found it highly impregnated with lead.

In my own practice, I have never met with any cases of decided encephalopathy. In consultation, I have seen two or three; one, Dr. Huntingdon's patient of this city, and one at Manchester, N. H., under the care of Dr. Josiah Crosby: the former proved fatal; the latter, a very interesting case, recovered. I trust, through the politeness of these gentlemen, you will be put in possession of detailed accounts of both cases.*

Several deaths among children, from affections of the brain attended with symptoms of an anomalous character, were, by the attending physicians, ascribed to the agency of lead water, taken as drink; but no *post-mortem* examinations were had, and I have not been able to obtain reliable reports of the cases.

* Two cases have been received from Dr. Crosby. No account of the other case has yet been received.

The two following well-defined cases were received by your Committee, from Dr. Josiah Crosby, of Manchester, N. H.

"Albert Taylor, thirty-eight years of age, of good constitution, and of very industrious temperate habits, an iron-worker in the repair-shop on the Amoskeag Corporation, in Manchester, N. H.; moved into a new tenement belonging to the company in the autumn of 1849.

"The water to supply his family was drawn through a lead pipe, 1½ inch in diameter, and 75 feet long, from a well 5 feet diameter, having 20 feet of water and nine lead pipes of the same dimensions as his, reaching to the bottom. His family consisted of himself, wife, and one child.

"The water on this corporation, generally, was not good, being impregnated with iron, some of it largely—but was generally denominated *hard*. This well was an exception; the water was much softer, and considered excellent to drink. Mr. Taylor was very fond of water, drinking nothing else, and drank very freely, and with so small a family they probably did not generally pump all the water from the pipe before using it.

"In January, 1850, Mr. T. began to complain of constipation, colic, and pain in the limbs and thorax; with loss of appetite and occasional vomiting. During this month and the two following, he was under my care, and a part of the time at his work, but too sick to attend to his business much of the time. In April, he went into the country; after a few weeks he returned very much improved, and went again to his work in the shop; in a short time he began to feel all his former difficulties return upon him, and so he continued through the first year of his residence in this tenement. Up to this time, his disease had been considered by his friends as resulting from his long confinement to the shop. 'The shop is killing him!' was the language of all his shop-companions, notwithstanding I had expressed my opinion strongly that it was lead in the water.

"In August, the colic and neuralgic pains in the thighs, arms, and thorax had become so severe that he was unable to sleep much at night, groaning and twisting himself continually; had but little appetite, and, when food was taken, it would produce great distress and frequently vomiting—so much so, that he often took no supper.

"In September, he painted all the lower part of his house, and remained in it with his family during all the operation of painting and drying. This seemed to produce an explosion, and his disease was soon and fully developed; all the symptoms were greatly aggravated; he had three forms of the lead disease—colic, paralysis, and arthralgia, all at the same time—having now, for the first time, the addition of paralysis of the sphincter of the bladder, which allowed the urine to pass guttatim. His case now became alarming; he could take but little nourishment, and this was often rejected; got but little sleep, and this never quiet—always disturbed; often getting out of bed, and wishing to go home; sometimes not recognizing his family;

thought they were conspiring to kill him; almost daily vomiting of a green, bilious fluid; the pain in the head, thorax, inside of the arms and thighs, was at times so intense as to produce furious delirium; his bowels all this time were very costive, and not moved but by powerful cathartics; when quiet, he would lie on either side, generally on his left, with his thighs pressing against the abdomen; taking no notice of anything about him, unless roused by pain or an attendant; the pupils were largely dilated; pulse 45 to 50; about fifteen inspirations in a minute; urine very scanty, four to six ounces in a day, and high coloured; *gums very blue.*

"In December, he had four fits; two at intervals of several days, and the other two on the same day. The emaciation was extreme; the parietes of the abdomen seemed glued to the spine, with no elasticity; I could grasp the curvature of the spine in the hand, and take hold of the descending aorta with the thumb and finger.

"This case was so severe, and continued so long, it would make a long chapter to give the treatment in detail. I shall therefore only mention those means which seemed to afford the most relief; cathartics, warm bath, in which was dissolved the sulphuret of potassium, and anodynes were the remedies which had the most control over the neuralgic pains, both of the colic and arthralgia, which I consider the same, and requiring the same treatment.

"The cathartics which I found best adapted to this case were castor and croton oils; sometimes they were administered separately, and sometimes combined. I think they afforded more relief when given together.

"I consider the warm bath with sulphuret of potassium a remedy of the greatest value in relieving the pains. Immersing the patient, and also the local application of the solution with flannels, applied hot to the bowels, thighs, arms or thorax, whenever the pain is most severe, and friction with the same solution, was of great service, the patient expressing great satisfaction from its use.

"The whole catalogue of anodynes was tried; morphia was the best, and the only one that accomplished much. Chloric ether was applied to the head externally, and was also inhaled with benefit.

"The paralysis, so far as manifested in destroying the action of the sphincter of the bladder, was more readily overcome than any other symptom in the case. Strychnine internally administered, in doses of from one-sixteenth to one-twelfth of a grain, three times a day, restored the action of the sphincter in about three weeks, so that the patient could control his water.

"In this case, I could do nothing specifically for the encephalopathy. The patient was so reduced, we could only support as much as possible his strength by nourishment, wine, brandy, cider, &c.; expecting daily that death would terminate the case; but, notwithstanding the extreme prostration and emaciation, Mr. T. has perfectly recovered, and enjoys at this time as good health as ever. He was away from his business six months.

"On the 8th of August, 1851, I was called seventeen miles into

the country to see Mr. W., thirty-five years of age, naturally of robust constitution, corpulent, temperate, of active business habits, (farmer, and deputy sheriff), who had been confined to his house and bed for several weeks with what was considered "liver disease," accompanied by yellow skin, severe colic pains, and extreme costiveness and vomiting; pulse slow; urine scanty; *gums very blue;* neuralgic pains in the limbs and back, and sleepless nights.

"On inquiry, I learned that he had never been able to get a good supply of water at his house, on account of a ledge of granite, which came very near the surface of the ground, on which his buildings stood; and that two years before he had sunk a well *twenty-two* rods from them, and had drawn the water that distance through a lead pipe, by a pump in the house, for all household purposes; that it took five minutes smart pumping to bring fresh water from the well. This explained the whole difficulty; the diagnosis was clear, and the treatment too; a supply of pure water, cathartics of croton and castor-oil to remove costiveness, and anodynes to abate the pain, constituted most of the treatment, and the patient soon began to improve, and ultimately recovered perfectly.

"From observations made in the management of a large number of cases, I am of opinion that all cases, not complicated with other and older diseases, would recover—perhaps not quite so soon—but would in a few weeks recover, by discontinuing the use of water drawn through lead pipes.

"I have related this case to show how nearly some forms of lead disease may simulate other and very common diseases, produced by very different causes. Here were exhibited all the symptoms of a severe case of jaundice, accompanied by severe colic; and would have been speedily cured by the treatment that had been adopted, had it been the production of common causes. It was only necessary to withhold the lead to effect the cure.

"I understand the opinion has been recently advanced, by some of high medical authority, that there is no such *specific form of disease* as that called 'Lead Disease,' not even in painters, and that the blue margin of the gums is not evidence of the presence of lead in the system; that it is shown in cases where the disease could not be attributed to lead. Now my belief is that we have had in this city more than a hundred cases of disease, the product of lead taken into the stomach by using water for drinking and cooking that was drawn through lead pipes.

"I consider the fact as well settled as any fact can be; as certainly as that the contagion of smallpox will produce the genuine smallpox.

"I have found *blue gums* in a large proportion of cases exhibiting the colic and arthralgic symptoms, and in every case of paralysis and encephalopathy. I do not consider its presence always necessary to settle the diagnosis of a case, but always sufficient to settle it when it is present. I think I have never seen, certainly never noticed such *blue gums* in any case, where it could not be attributed

to lead. I have seen the blue lines present in several members of the same family at the same time, when only one manifested the symptoms of the disease; and by changing the water the blue has disappeared in every one so affected. This has been the result always."

The following are the only two, of numerous cases, brought under the observation of the chairman of your Committee, either as attending or consulting physician, which he proposes to introduce at this time. He has preferred to lay before the Association those furnished from other reliable sources from different parts of the country. By so doing, the fact has been shown that the diseases in question have not been confined to a limited space, nor to a small number of observers. All the cases reported, except those designated as coming under the observation of the Committee, have been furnished in answer to the circular issued by them in the early part of December last.

I was called, in October, 1851, to see A. C., aged 32, of rather slender constitution. It appeared that, about three months previous, he had an attack of pain in the abdomen, which was relieved by evacuations. This was followed by an uneasiness, nearly constant, in the bowels, constipation, and by occasional attacks of pain, like that just described, but less severe; this uneasy sensation led the patient constantly to hold on, or press his hands upon the bowels. The skin had a sallow, dingy appearance; the white of the eyes was quite yellow. These symptoms had led his friends to believe his disease was jaundice; there was loss of appetite and flesh, his spirits were depressed, tongue lightly coated, breath offensive, pulse 76, small; his whole physiognomy was precisely that indicative of lead poison. On examining the mouth, found the points of the gums, which project between the teeth, stained blue. The urine was rather more coloured than natural, but on examination (subsequently made) did not present that peculiar play of colours with nitric acid, said to be indicative of the presence of bile; the excrements were rather darker than usual, showing a sufficiency of bile. I did not hesitate to pronounce it a case of lead poisoning, from some source or other. On inquiry, I found that he had been drinking lead water for something more than two years. The treatment consisted in regulating the alimentary canal, which was done with a moderate amount of medicine, and abstaining entirely from the use of the water. In one week, his countenance began to clear up; the distressing sensations about the bowels were soon mitigated, and finally entirely relieved in about three weeks; had no attack of severe pain after the discontinuance of the water; has remained well since, a period of five months.

This case is reported as showing a well-marked case of lead poisoning; its physiognomy could never have been mistaken by any

one who had ever been familiar with lead maladies. More of the premonitory symptoms were present than are usually observed in any one case, viz., the blue gums, the fetid breath, the jaundiced appearance of the skin and eyes; yet no one of the four forms of lead disease laid down by Tanquerel was ever well developed.

The intelligent and reliable record of the following case was furnished me by the patient himself, who is a gentleman of wealth and education, and a graduate of the Boston Medical School; but he has never entered upon the practice of the profession. He was under my immediate observation during the continuance of the treatment, and at my request he kept a daily record of his own case.

DR. ADAMS:—

My Dear Sir—At your request, I write down what I recollect of the state of my health before your treatment of me for lead paralysis, in the summer of 1848. My health had not been very good for many years, but my strength failed more perceptibly during the two years previous to that summer; and, in the winter previous, I felt an increasing unwillingness to make any physical exertion, and great listlessness. This was made evident in working the foot-treadle of a lathe, which had furnished me exercise for three or four years. I could not keep at work long, and found, on comparing myself with others, that I was unable to turn it so fast as they.

I spent three months of that winter in Boston; our rooms being in the fourth story, and the staircase long and rather steep, I never went up without fatigue, and often sat down to rest. I remember, too, an uncertainty in going down, and more than once slipped (as I then thought) and should have fallen, but for the banister.

In the latter part of March, being in the saddle, my horse fell with me, and my shoulder was dislocated. Had I been as vigorous as formerly, I could have held him up, but I felt conscious that I could not brace myself up from the stirrups.

I recovered the use of my arm, and we returned to our home in Waltham towards the end of April; from which time to the first of July, it became still more evident that my lower limbs were failing. On one occasion, I started to run a short distance, and fell forward flat; my legs seemed not to obey the will. Two or three times, while standing or walking on the smooth floor, my knees suddenly bent and I fell. I fell repeatedly while dressing. And during that spring I complained, after an hour's drive in a gig, of a cramped feeling in the thighs—so uncomfortable that I seldom drove in any vehicle in which I could not stretch the limbs straight.

All these symptoms I detailed to you on the evening of the last day of June, and added that I began to feel a numbness over the left thigh and buttock, with a diminished sensibility.

You inquired about the water used in the house, and I told you that that for cooking passed through 140 feet of lead pipe to the

kitchen-pump, and that I had used it for nine years: that for some months past I had made my breakfast of crushed wheat, which, after soaking in water all night, was put on to boil the first thing in the morning, and probably the water which lay in the pipes all night was used for this purpose. The drinking water chiefly used was brought through 40 feet of lead pipe from another well to another pump.

You then said that you believed that I was suffering from lead held in solution in this water, and asked me to let you have some of it in the morning for analysis. On the following day I called on Dr. James Jackson, to ask him about other matters, and before I left his study I told him of the symptoms I had detailed to you, and also of the opinion that you had expressed, Dr. Putnam being present. He said that it might be so, and that he had great respect for your judgment; but that he had not observed in his practice any case of paralysis of the lower limbs from lead which had not been preceded by some affection of the other parts of the body, particularly colic.* He examined my spine thoroughly, with Dr. Putnam, and found no evidence of disease there. Still he recommended, as a matter of prudence, the application of twelve leeches to the lower part of the spine, and to be followed by a blister on the same spot; which was accordingly done.

The next day (the first of July) you took for examination two phials of water, the first pumped that morning from both pumps. On being tested with sulphuretted hydrogen, that from the kitchen-pump became *very* dark; and, after standing till the next day, looked like ink and water. That from the other pump was coloured, but less highly. I discontinued the use of both waters from the first of July.

The day after my blister had been dressed, I called on Dr. Jackson again, and took with me the phial of blackened water, at the sight of which, he confessed that he believed that your opinion was well founded, and that he thought I might safely omit the treatment for disease of the spine.

I remark in this connection, though anticipating a little, that another gentleman, equally eminent in his profession, examined my spine, a few weeks afterwards, to whom I had also mentioned your diagnosis, and though he found no tenderness in any spot, he suggested the application of caustic to the lower part of the spine.

For two, or perhaps three weeks, I walked every day a little for exercise, though with great and increasing difficulty. A spasmodic working of the feet from side to side troubled me, and they would often draw back out of the shoes. I was unable to draw on a boot. While sitting still, the legs would insensibly draw back on the thighs, till the feet got entangled under the chair. This involuntary draw-

* The experience of Dr. Jackson on this point differs from that of the chairman of your Committee. Of 11 cases of lead paralysis falling under his observation, in 6 paralysis was the first form of lead disease observed; and in 5 cases it was seated in the lower extremities.

Out of 102 cases of paralysis observed by Tanquerel, 39 were not preceded by any other form of lead disease; and in fifteen only was it seated in the lower extremities.

ing back of the leg made it very difficult to go up stairs. I recollect that the last time I went up (Aug. 10), a man held the foot on the first stair, while a person behind assisted me to rise so as to place the other foot on the next stair; and then the man would hold that foot in place, or it would certainly have drawn back so as to have thrown me down. While going down stairs, I straightened the whole limb before planting the foot upon the next step, and, with the help of a man and the banister, could get down safely. But on the 11th August my bed was moved to the lower floor, and I did not attempt the stairs again till the 25th October.

The numbness, before spoken of, affected the *right* limb a day or two after, and soon extended over the whole of both limbs, from the buttocks to the toes; and, for a long time, I so lost the sense of feeling in them, that I had no consciousness where the feet were, unless I saw them: for many weeks I did not know whether one foot touched the other in bed. There was also an unnatural coldness of the lower limbs, uncomfortable to myself, and perceptible to the touch of others. I wore my warmest winter clothing all summer, and always had a blanket shawl over my lower extremities, even the hottest days, when taking my drive, which I did almost every day that summer. In the house I used an India-rubber water cushion to sit upon, and had it filled with warm water every day. Since my recovery, I have felt more warm than before the crisis, and have especially observed that my feet are not so cold as formerly.

It was very perceptible to me, as well as to yourself and others, that the glutei muscles on the buttocks, and the large extensor on the front of the thigh, were greatly wasted; while the biceps and flexors, from the trochanter of the ilium to the tibia, were unusually strong and active, indeed, in a constant state of contraction; and I suffered much from cramp in this muscle, and in different muscles of the leg and sole of the foot. And when I found that Tanquerel lays down a principle, established by facts, that, in lead paralysis, the extensor muscles are always weakened and more or less wasted, while the flexor muscles continue in their usual vigour, I was convinced of the correctness of your diagnosis.

The difficulties in the different motions, as before described, agree with this law: I could not run, because I could not throw forward the leg, nor push forward, by straightening out the foot and rising on the toe. The foot drew back on the stair, and the leg drew up under the chair, because one set of muscles was more vigorous than the counteracting set. And, in walking, the foot would twist about and draw out of the shoe, and the muscles of the sole contract even to a painful cramp, because there was no balance of power.

On the 6th August, I began a daily minute of the symptoms and the treatment which I kept till the second week of November. From the 8th of August to the 25th, I could not get up out of my chair without assistance, nor stand alone even on crutches. On the 28th, I raised myself erect by placing my hands on my knees and let myself down again pretty well.

Aug. 29. Walked with ease and confidence on crutches without other help.

Sept. 14. Manifest improvement in walking and standing; since two or three weeks, I can do many things alone that I could not do without help. Indeed, until a short time before this date, I was quite unable to put on my clothes, or to wash myself, or to undress, without help.

16*th.* Walked round the garden with a cane (discarding the crutches), and holding upon another person's left shoulder with my left hand, bearing almost all my weight upon my legs.

Same day, in the house, walked about a dozen steps entirely alone, without crutches or cane, and back again.

17*th.* Walked about alone on crutches more than I have done any day for many weeks. Glutei muscles said to be very perceptibly enlarged, especially the left.

18*th.* Could stand while I washed my face and hands without taking hold and without help, which I have not done for five or six weeks at least.

20 *th.* Walked out of doors on crutches, without other help.

21*st.* Walked half a mile with my wife and a cane; carried a lighted candle in my left hand from one room to another, using cane with right hand.

24*th.* Went to church in Boston in the afternoon, not much fatigued.

Oct. 1. Went to church in Boston all day; not more fatigued than other days. In the morning, took my douche standing, for the first time.

2*d.* Played two games of billiards, one hundred each, and beat both.

19*th.* Walked a mile with my wife and a cane.

20*th.* Walked a mile with cane only.

25*th.* Out of doors on my feet with a cane only, for three hours, besides driving myself in a wagon about four miles.

During the following winter I walked every day, and often from four to eight miles with a cane, but I have not ridden on horseback with confidence till this winter, and, even now, have not a very firm seat. I can walk as fast as I ever did, but am very awkward in my movements in a room and in running. I cannot walk a single plank steadily. I never go down stairs now without taking hold of the banister, if there is one, or resting on a cane. If I attempt to walk in the house in the dark, without a cane I totter; out of doors with a cane, I am unsteady. While washing my face in a wash-bowl, my eyes being shut, there is a tendency to draw back; and to this day, I never for a moment forget the existence of the flexor muscle on the back of the thigh; it is, indeed, developed out of proportion to the other muscles, and seems to be in a constant state of contraction, and this I believe to be the principal cause of the unsteadiness and awkwardness that remains.

I have, from time to time, very sharp neuralgic pains, which I

first felt in the winter of 1846–47, owing, I believe, to the state of the stomach; but it is a singular fact that they are always seated in the lower limbs, though not limited to the joints, nor to any particular spots.

There is one fact which I have omitted; the bladder was very much weakened. It was slow in recovering, and has not yet its full natural power.

The treatment was chiefly the use of strychnine and of electro-magnetism. With the last I began early in July, applying it to the whole limb from the buttocks to the foot, putting on the metallic slipper. The effect was not good, for it increased the spasmodic action of the limb, and especially of the foot. But afterwards, on applying the wires to the extremities of the weakened muscles, and under the influence of strychnine, I found a happy result; for it stimulated *them* into action without affecting the healthy muscles. Early in August, I read Dr. Dana's translation of Tanquerel's invaluable work, and proposed to you to try the effect of strychnine, and with your approval I began, I believe, on the 2d or 3d day of August, first with a pill of one-sixth of a grain, the next day a pill morning and evening of one-sixth grain each, and on the 6th one-third of a grain in the morning and one-sixth at night. The effect of the first dose which I took was very similar to that of electro-magnetism, particularly the feeling in the foot; it was like the rapid succession of little electric shocks in the foot, with a sort of creeping sensation through the limb. The larger dose on the 6th, I took at ten A. M.; at noon, the muscles about the mouth twitched spasmodically; at half past two P. M., there were very strong contractions of the muscles of the lower limbs till three o'clock. Twitchings about the mouth continued till between four and five, whenever I attempted to speak.

On the 7th, I took half a grain.

On the 8th, I took two-thirds of a grain at ten minutes past ten A. M. In twenty minutes I began to feel light-headed, with great difficulty of breathing, which led me to suppose that I was fainting. I laid myself flat on my back on the floor, and got no relief. I raised myself on end, which caused a strong convulsion. The man-servant took me up to lay me on the sofa, and, while in his arms, there was a powerful spasm of all the muscles of the body (as it seemed to me), intensely painful for a moment; this subsided on being laid down. I could hardly breathe while the head was down; breathed a little easier on being bolstered up. I found that I was instinctively raising the shoulders at every inspiration. Sensibility was extreme; so much so, that the resting of a fly suddenly on the nose caused a spasm, which lifted the whole body from the sofa, arched up, as in locked-jaw cases. The same convulsion was caused by any one touching me unexpectedly. A person who came into the room and sat down opposite to me, caused such a commotion in my whole frame that I was obliged to request that she would go out. The pulse was eighty-four, intermitting about every tenth stroke. Great twitching

and jerking of the muscles round the mouth. I could speak only in a whisper. The jaws were held tight together, so that, even after some time, it was very difficult to get a little water into the mouth; after I got it into the mouth, I swallowed it. Occasionally there was involuntary gritting of the teeth. Pain in the nape of the neck very severe, so that a man's whole force was exerted in pressing against it. At eleven A. M., I began to inhale chloroform; from two to four full inspirations at a time, repeated as often as the spasms became more violent. This acted like a charm; it kept the spasms under, relieved the breathing, and, in an hour or two after first taking it, the intermission of the pulse entirely ceased. The symptoms continued, though gradually diminishing, till between two and three o'clock. At a quarter before four, I was able to sit up and eat some dinner, and between five and six o'clock, I took a drive in the carriage.

My minute in the evening was, excepting weakness, not much worse than the few last days. The pill to-day was from a new parcel of strychnine and fresh made. The next day I took one-third grain in the morning and one-sixth grain in the evening, and I continued the same dose until the 31st, except the evening pill, which I took only two or three times. Twice, during that month, I took five-twelfths of a grain with symptoms similar to those on the 8th, but much less violent. In both instances, I found great relief from chloroform. During the rest of the treatment, I took usually, during the month of September, one-sixth of a grain daily, and until the 9th of October; from which day till the 9th of November, I used daily one-third or one-fourth of a grain, and twice only one-half of a grain, omitting it for a few days when very much reduced. The electro-magnetism was applied generally three times a day, once to the glutei muscles for half an hour, and twice to the extensors of the thighs, one-quarter of an hour each.

On the 7th and 9th, I took a sulphurous bath at 98°, three-quarters of an hour each time. But it reduced my strength so much that it was given up. I took daily a dose of flowers of sulphur. I continued the use of strychnine till Nov. 9; and, in the following winter and spring, I used it for a short time, at three different periods only, twice in pills as before, and once sprinkled on a blistered surface; in both methods with effects similar to those before experienced. While under its influence, there is much more vigour in the lower limbs, but I observe nothing similar in the upper extremities. It affects my general health to such a degree that I have not the resolution to persist long in the use of it again.

The result of my experience of it is, that it has more effect on the weakened than on the healthy muscles, though it does not act *exclusively* on them. I observed this especially as I began to gain control over the limbs. I could feel at every step that I had a power over the glutei muscles and the extensors on the front of the thighs which I had lost. Under full doses of strychnine there was a feeling of great tenseness and rigidity, and an indescribable sensation of

compression of the whole limb. I speak of them on the 31st August, in my journal, as feeling stiff and hard almost as iron. When under the full influence of the medicine, I usually slept a heavy, lethargic sleep, from which I was roused, every now and then, by a sudden jerk of the lower limbs, as if an electric shock had passed through them. The spasmodic motions of the foot gradually diminished, after a week or two from the first dose, and disappeared towards the end of August.

The general effects of the medicine I found very remarkable. Under its full influence, the pulse was usually 96; never observed lower than 84, and in two hours it would fall to 64 and 60. There was also a tendency to intermit, though never so frequently as on the 8th of August.

The breathing became difficult, and this appeared to be caused by a contraction of the diaphragm, as shown by the extreme difficulty of breathing, while flat on the floor, and, when raised, by the action of the shoulders and intercostal muscles.

There was always more or less twitching of the muscles about the mouth, particularly on attempting to speak, eat or drink. Pain in the nape of the neck was caused by the larger doses only.

There was always great nervous sensibility, amounting, sometimes, to a sense of distress impossible to describe. All these effects became more violent under the slightest mental excitement. After a long use of strychnine, the system seemed to run down, the appetite diminished, costiveness increased; and constant headache, stupor, lassitude, and weakness were produced.

I cannot conclude, without an expression of my sincere gratitude to you, for discovering the true cause of my complaint, and for your unwearied attention and kindness in the treatment of it. Nor can I refuse to recognize that, under the blessing of our Heavenly Father, you have been the instrument of saving my life. For, had I been treated for disease of the spine, without a suspicion of lead, I cannot but think I should have sunk under it.

I am truly and gratefully yours,

J. S. COPLEY GREENE.

WALTHAM, *April* 12, 1852.

There are two points in the treatment of the preceding case worthy of particular notice: 1st, the fact that the administration of the strychnine was continued, with but slight interruption, for a period of three months, in doses of sufficient magnitude to produce some twitching of the muscles, generally slight, but sometimes severe.

2d. The fact that, in the application of electro-magnetism, the stream was carried through the diseased muscles only, by placing one pole at the origin, the other at the insertion of the muscles to be acted upon. When the whole limb received the shock, no beneficial

effect was produced; the well and diseased muscles being equally excited by it.

The committee have shown the action of water on lead pipe, and they have also endeavoured to show the nature and character of some of the diseases produced by the domestic use of such water; and reported cases illustrative of the subject. They will now present some additional facts in support of these views, and add some brief comments on the more important statements and conclusions recorded in the foregoing pages.

It has been shown that natural water, when brought in contact, *always acts on lead*, and that the *various theories of the cessation of action, after a certain length of time, are not true*, and are in no case supported by the facts of experience. The Cochituate water, drawn through lead pipes laid four years ago, continues, at this time, to present very notable traces of lead. In New York, the Croton water, even at the present day, drawn from leaden hydrants put down ten years since, is impregnated with lead, and your Committee are credibly informed that diseases which can only be ascribed to this poison are not of unfrequent occurrence in that city. Dr. George H. Kingsbury has published, in the *N. Y. Journal of Medicine* for May, 1851, four cases of obscure disease fairly attributable to the use of Croton water drawn from lead service pipes. We make the following quotation from his report:—

"Since the introduction of Croton water into the city, cases simulating lead colic have occasionally been met with; yet, in the absence of the usual and well-known causes of that disease, and the seeming improbability of a sufficient amount of lead poison being held in solution by Croton water from passing through lead pipes, the symptoms have usually been ascribed to other causes or left altogether unaccounted for."

In two of the cases reported by Dr. K., the patients suffered repeated attacks of lead disease, before the true cause was suspected; when suspected and removed, there was no return of disease.

In New Orleans, the inhabitants appear to have suffered more from lead diseases than those of any other large city within the knowledge of your Committee. According to Dr. Fenner, who has published two elaborate reports—one in 1850 and another in 1851—the first on epidemic colic in New Orleans in the summer of 1849; the second, on lead poisoning, in the same city, in 1850—it appears that colic was epidemic during both the summers of 1849 and 1850, and that it presented the appearance of lead colic, which led Dr. Fenner to

investigate the cause of it. From this investigation he came to the conclusion that it was mainly due to lead poisoning, derived from three different sources, viz., soda fountains, where this beverage is drawn through lead tubes, and the hydrant water of the city, which is delivered through lead service pipes, which were put down in 1837, and the cistern water, which is collected from the tinned roofs of the houses.* Lead has been frequently detected by him in all these different varieties of water.

According to Dr. Fenner, the colic of 1849 bore a close resemblance to lead colic, and was frequently attended or followed by rheumatic pains, as they were then denominated. The disease was not inflammatory, but was generally considered a neuralgic affection.

It appears, by the report on lead poisoning in New Orleans, that the same disease again prevailed during the warm season of 1850. There were admitted, during this year, into the Charity Hospital of that city, 137 cases of colic, of which 51 cases are recorded as colic, and 83 as colica pictonum, and 3 as bilious colic. A large proportion of these cases occurred between the first of May and the last of October. It also appears, by the same report, that some other diseases, known to proceed from lead poisoning, were very prevalent. According to Dr. Simond's statistics of mortality in the city for the same year, the number of deaths from apoplexy were 115, from congestion of brain 101, from epilepsy 16, convulsions 354, from paralysis 19. Of these, 403 occurred in the summer and autumn, and only 202 during the winter and spring; corresponding in this particular with the cases of colic. The above-named diseases, according to Tanquerel, are often produced by lead poisoning; and all lead diseases are more common in warm than in cold weather. Of the 354 deaths from convulsions, 330 were children. It is not unfrequently the case that the first development of disease among children from lead poison is in the form of convulsions.

Dr. Fenner, in a letter addressed to the chairman of your Committee, in speaking of the diseases of New Orleans in 1851, says:—

"I am decidedly of opinion that *encephalopathy*, *arthralgia* (*vulgo*, *rheumatism*), *neuralgia*, and *paralysis*, arising from *lead poisoning*, prevail in this city to a considerable extent. In our large Charity Hospital, in the year 1851, the number of cases admitted for the various affections that are known sometimes to arise from lead poisoning are as follows: viz., colica pictonum 72, bilious colic 17, colica convulsiva 1, apoplexy 19, epilepsy 12, amaurosis 3, con-

* The so-called tin used for covering buildings is made mostly of lead.

gestion of the brain 19, convulsions 9, paralysis 29, neuralgia 17, rheumatism 358.

"Knowing that the exposure to lead is very great in this city, I have no doubt that it had the chief agency in the production of a large majority of the above cases. The colics marked *bilious* were precisely like the *painter's* colic; and a large number of those marked *colica pictonum* did not occur among *painters*. The congestion of brain cases may have arisen from a variety of causes. The *convulsions* occurred mostly among *adults*, and I have no doubt mostly depended on lead poisoning."

In support of this opinion, he adds:—

"In one patient, immediately after recovery from convulsions, the *wrist-drop paralysis* supervened, establishing the character of the disease. Other cases like this have been observed at this hospital; as also cases of colic and convulsions, which could not be indubitably traced to lead, but which yielded alone to the treatment appropriate to lead poisoning.

"Neuralgia prevails in this city to a great extent, and lead may certainly have something to do with it. As to rheumatism, it is certainly very remarkable that it should prevail here chiefly in the warmer portions of the year, as I have shown in my report."

Many other very interesting facts are to be found in Dr. Fenner's reports, and your Committee regret that their limits will not allow them to extract more freely. The Dr. has performed a good service both for the profession and the community in which he resides, and if they do not both profit by his researches, he certainly will have the satisfaction of having early pointed out the impending danger.

In Cincinnati, as appears by a letter from R. Jay Kittredge, M. D., published in the *Southern Medical Reports*, vol. i., lead diseases are not unfrequently met with, although often treated under another name, and that notable quantities of lead are found in the water drawn through lead pipes.

Your Committee ~~fear~~ that sufficient evidence has been adduced to show the continued action of water on the lead pipe through which it passes.

The next point your Committee will notice is the great difference in the length of the exposure of individuals to lead influences before disease is developed—varying from a few weeks to something more than nine years. This may in part be owing to the intensity, or degree of strength of the poison introduced into the system. Extremely minute quantities may be taken for a great length of time, before there will be sufficient accumulation to produce disease. The minuteness of the quantity of poison in water, which may in time

produce disease, cannot be limited; less than 1-100th of a grain per gallon has been known to produce it. The chairman of your Committee has now under his care a case of *paralysis* of the muscles of the forearm, hand, and fingers of one limb, produced by lead water, where no trace of the metal could be detected by the most delicate tests, till the water had been concentrated fifty per cent. By the tests above used, 1-100th of a grain of lead per gallon can be detected in natural water.

But this discrepancy in the length of exposure before disease is produced may be mainly owing to difference of susceptibility in the exposed. This difference of susceptibility is due, no doubt, to different degrees of constitutional vigor or energy; and it is possible that this may in some cases be so great as to render the *individual comparatively impregnable* to the action of this poison. Dr. Dana, in his report on this subject to the City Council of Lowell, makes the following apposite remarks:—

"The constitution is only a greater or less degree of vital force. Life is vital force, manifested under the control of a higher influence; the nervous influence, it may be, too spiritual for the cognizance of our senses. The vital force is as much a power as is electricity, magnetism, light, and heat. All agents act chemically on the tissues of the living animal body, as they would upon dead matter. Their agency is limited and controlled by the vital force. If that is strong, so much less is their action. One man differs from another, as a horse, for instance, differs from a man. A horse may take daily, for weeks, several grains of arsenic, without other effect than a softer and more silky skin. In this sense of the constitution, a difference, in degree only, of that agent called vital force, it is found by experience that the young, the delicate soonest succumb under the effects of lead drank in their daily drink, and like the dews of heaven, descending on all, the gentlest and fairest feel the chill which soon closes in death."

There is in the community, and even among medical men, an unwillingness to admit that this poison is productive of much evil; they urge the exemption of a certain portion of those exposed, either entirely or in a very great degree, from the injurious effects of this poison, as an evidence that these are, in all the supposed cases, imaginary. The same argument might be used with equal truth against the existence of malaria, or the poison of most epidemic or contagious diseases, inasmuch as but a small portion of those exposed become actually infected. Cholera scarcely decimates the community among whom it finds its victims, and influenza, even, leaves many untouched in its less *partial* course. Another ground of scepticism has been the

fact, that cases, having the features of the affections attributed to the agency of this metal, are occasionally met with, in individuals, not yet suspected of being exposed to its action. But when we reflect to what a variety of purposes, connected with domestic life, this metal has been put, through which it may be insidiously introduced into the system, such cases may *all* ultimately prove (as *many* of them have already been proved) to be mere apparent exceptions. It is well known, that the oxides of lead enter largely into the composition of the glazing of earthen and stoneware. It is readily acted upon and dissolved by acids; hence, whatever articles to be used as food, which contain acids, are kept in these vessels, must act upon this glazing, and be more or less liable to produce the peculiar symptoms of this poison. Numerous cases in point could be cited, but we will only mention one which occurred some two or three years ago in Ohio. The following account of it is gathered from a letter addressed to your Committee, by Dr. E. C. Bidwell, of Keen, Ohio.

It appears that a cheap kind of earthenware came into use in a certain section of Ohio. Soon afterwards, a very strange disease made its appearance, and was variously denominated *Dutch belly-ache, dry cholera*, &c. Many deaths occurred from it before its character was understood. Dr. Bidwell says:—

"A case occurring in my practice which I had determined to be of saturnine origin, although unable to indicate the source of the poison, I soon afterwards ascertained it to be precisely similar to the disease which had become endemic in that locality.* This led me to make such an examination as immediately satisfied me that the lead employed in the glazing of the earthenware was the true cause of the alarming disease."

The following extract of a letter, recently received from Dr. Mason, of Billerica, strikingly verifies the difficulty, under certain circumstances, of identifying the cause of the disease.

"When I practised in Dedham, I attended upon the family of Mr. Mark Guild, whose wife and mother seemed to me to be clearly poisoned by the long use of lead. I communicated my suspicions to them, but they denied that they were at all exposed to the use of that article. They drew their water from a well, and used no lead utensils in the family. There was a small mine of very pure lead in the vicinity, which had been opened a few years before, but was then deserted. This mine was afterwards reopened by a company on speculation, and the grounds explored around. The result of the

* Dr. Bidwell did not live in the immediate vicinity of the diseased neighbourhood.

exploration was that this well was found to have been dug through rock containing a portion of the lead vein."

It is to be hoped that the profession will soon become so familiar with the diagnostics of lead diseases, that they will be able to recognize them with more certainty than is now generally done, and treat them with their appropriate remedies, although the source of the poison may not be detected. In many other forms of disease, we prescribe in full confidence of our diagnosis, although the causes producing them may remain hidden from our view. (See APPENDIX C.)

The several members of your Committee have not unfrequently met with cases of chronic disease, which have for months, and in some instances years, been unsuccessfully treated for neuralgia, dyspepsia, jaundice, and more especially rheumatism; which they were compelled to believe had their formation in this poison received in some unsuspected way into the system. Such cases have generally yielded to appropriate treatment for lead maladies, particularly if the source of the poison could be discovered and removed; and in some instances where this could not be done, the patient has been removed to some other place of residence, when convalescence immediately ensued.

The different forms of lead disease, as laid down by Tanquerel, are often complicated with each other, and sometimes with other diseases. They are also very insidious in their approach, often creeping on very slowly, the symptoms for weeks, and in some instances months, indicating no very definite form of disease. At other times, the attacks are sudden. This is oftener true of encephalopathy than any other form of lead disease.

We must, for a moment, call attention to the remarks already made on the seat and nature of lead diseases. It was shown that lead poison produced an alteration in the brain and nervous system; that pathological anatomy, however, revealed no organic lesions; but that functional changes existed in the organs to which the fibres from the several nervous centres were distributed; hence, the varied seat of disease, as the different nervous centres were affected. But why, when the nervous spinal system is affected, for instance, sensibility should at one time be exalted, as in arthralgia, or entirely lost, as in anæsthesia, or the power of motion destroyed, as in paralysis, is not revealed to us. Under this view of the seat and nature of lead disease, we shall cease to be surprised at the variety of forms under which it presents itself.

In a manuscript lecture of the late Dr. Howe, before alluded to, in his quaint way, referring to the question under consideration, he remarks:—

"A large portion of the symptoms produced by lead in small quantities is saddled on to that everlasting pack-horse, called rheumatism. This rheumatism passes with 'the world's people,' as a noun of multitude, and affords a name which is vastly convenient for a host of indescribable twinges, darts, pangs, and girds, for which no names have been provided. Besides colic, minute quantities of lead, taken internally, will produce an almost infinite variety of symptoms, such as numbness of the hands and feet, swelling and pain in the finger-joints, pain in the back and limbs, slight convulsive twitchings of the face or eyelids, over which the patient has no control, and a multitude of others, varying in different subjects, and at different periods of life. These symptoms are sometimes so very tardy in their development, and come often in such a 'questionable shape' that the connecting link between cause and effect is often lost, and the disease prescribed for under mistaken impressions; for instance, a child becomes indisposed, is peevish and fretful; the eyes become heavy, it starts in its sleep, or has a convulsion fit. But what is the cause of all this? Why, to be sure, they will say, 'the child has taken cold,' or, 'it is feverish,' or, 'it has canker,' or, 'it is teething,' or——something else; but not a word is said about sugar-plums, peppermint, or candy. Nobody mentions the nicely painted doll, the trumpet, or the whistle; but each of these is ornamented with lead, which is liable, in various ways, to be decomposed and swallowed by the child; and it is well known that exceedingly small quantities of this metal produce the very symptoms just described. Let me entreat you, as you value the present and future health of your children, to protect them against the poisons of the 'toy-shop.'"

If, then, such a variety of symptoms is due to, and so large a number of the organs of the body become deranged by the agency of this poison, which in such a number of ways may be unconsciously received into the system, it is not strange that errors of diagnosis should be often committed by those of the profession to whose attention the subject of lead disease has not been presented.

Those practitioners who are persuaded that most of the chronic ailments to which flesh is heir are due to "*deranged liver*," will readily find confirmations strong of this prejudice in the sallow, dingy complexion, yellowish conjunctiva, constipated bowels, and pains in the sides and shoulders, which attend some cases of the affections we are considering. These patients will feel that their difficulties are more than half cured when they are pronounced to be "*very bilious.*"

Neuralgia and spinal irritation will, with those whose indolence cannot brook the labour of a cautious diagnosis, embrace a large portion of them, and this the more readily, since the resemblance is, in some of the cases, very strong, and particularly will this error obtain in regard to those in whom the two diseases (as often happens) unfortunately coexist. But even these complicated forms will, to an instructed eye, and under a searching analysis, become perfectly transparent.

Those imbued with the Broussaisian doctrine of "gastro-enterite" will not fail to find their dogmas confirmed by the irritable state of the stomach and bowels, tenderness on pressure over the epigastrium, and frequently recurring stitches and pains, emaciation and deranged secretions, which constitute the livery of some forms of this protean affection; and forthwith the sufferer must be subjected to an everlasting succession of leeches, rubefacients, ptisans, and enemas, and to a shadowy nutriment, embraced in the fearful phrase *diète absolue*. Some cases within the observation of at least one member of the Committee have been mistaken for, and treated as subacute or chronic peritonitis, though we think this error can scarcely be committed, except by those whose diseased imagination compels them to detect a latent fire, ready to burst out, momentarily, into open conflagration, whenever tenderness on pressure (no matter how small the amount) can be made to coincide with abdominal pain. One or two such cases from histories received, on being summoned to hurried consultations, near the closing scene, led to more than a suspicion that they had been brought to a fatal consummation by the sanguinary proceedings of one of these graduates of the Sangrado school of medicine; a *post-mortem* in one of them betraying not the slightest trace of preceding inflammation, the other not being examined.

The pains in the back and loins, and the occasional dysuria, will, in some cases, lead the observer strongly to suspect nephritis; and in some others, he can hardly persuade himself that his patient is not labouring under an attack of gravel. And these cases will yield their obscurity only to the most vigilant scrutiny and careful inquiry.

To the unsuspicious or inexperienced observer, the disturbed condition of the digestive organs constituting the more prominent derangements in some lead affections at a certain stage; dyspepsia, in all its protean varieties, will at once be suggested, and a corresponding treatment, without reference to the true cause, be adopted.

Cases of diseased brain, within our knowledge, have gone on to a

fatal termination without a single suspicion as to their true origin, and, of course, with the omission of a most essential condition of recovery in all diseases, viz., removal of cause, which, with the light thrown upon these affections from the luminous pages of Tanquerel, would at once have been recognized as cases of encephalopathy, and possibly have been guided to a fortunate termination.

Besides the above, for which affections arising from the poison of lead have been mistaken, we cannot but feel the strongest conviction that there are many anomalous and unnamed derangements and symptoms, which are met with by all physicians, which will hereafter be traced to lead as their cause, but which now, in consequence of its unsuspected agency, often baffle the most scientific, and in other respects the most judicious treatment, and consign their victims to year after year of suffering and decrepitude throughout a long life, or bring it to an early close, in an unexpected and unexplainable manner.

We have been struck with the immediate evidence of commencing convalescence which most cases exhibit on the cause being removed. Even the protracted and the more severe ones, which before this seemed to be only in a slight degree mitigated by the use of means employed, would at once, in the improved complexion, diminished pain, and more especially in an unwonted cheerfulness of manner and elevation of spirits, inspire both patient and physician with a confidence that certain immediate relief and ultimate recovery might now be relied upon. A buoyancy and elasticity of the feelings would begin at once to be manifested, which never were witnessed during the continued exposure to the cause, even when, by the treatment, the rest of the symptoms were most decidedly softened. In many instances, a conviction seemed immediately to be produced on the mind of the patient that his convalescence was now certain to be established. It was equally surprising how rapidly this array of symptoms was reproduced by a few weeks of renewed exposure to the unsuspected cause.

In conclusion, your Committee will only add that the settled conviction to which their labours, in preparing this report, have conducted them, is this: that it is never safe to use water drawn through lead pipes, or stored in leaden cisterns for domestic purposes, and that any article of food or drink is dangerous to health which by any possibility can be impregnated with saturnine matter. It may possibly be done in some cases with impunity, but it is *impossible to predetermine* the cases of safety where so many are fraught with danger (see APPENDIX D).

APPENDIX.

(A.)

SOME anomalous cases of apparent non-action of water on lead, derived from the absence of disease, are occasionally observed. They must be considered as exceptions to the general rule, but nevertheless are as important to be known, in the search after truth, as the more numerous facts establishing the general unsafety of the use, for domestic purposes, of water transmitted through lead pipe. The following letters, addressed to your Committee, from highly respectable sources, are of this character:—

DR. J. C. DALTON—

My dear Sir: Although Amherst Plain is well known to some of the Committee of the American Medical Association appointed to investigate the subject of the action of water on lead pipes, it may not be entirely foreign to the purpose to give some account of the natural location, soils, &c.

The Plain has a light sandy soil, but well cultivated is capable of affording very good early gardens. As you ascend the higher ground, the soil becomes richer—a dark, reddish loam soil—higher still, not quite so deep a soil, and coarser—above this, a mixed clay soil. And all these are well stored with New Hampshire granite.

The house I reside in stands on the margin of the higher ground —I purchased, and moved into it, I think, in 1808. The next summer was a dry season, and, to my disappointment, I found my well without water. This induced me to think of an aqueduct. On searching for springs, I found one 25 rods from my buildings—another 60 or 80 rods distant.

In 1820, a company was formed for bringing the water from my springs, and also from the springs in the hills on the other side of the road, to the Plain, in lead pipes; 20 or 25 families engaged to take the water. An equal or larger number have continued to be supplied by this aqueduct to this time. Other aqueducts, since laid and in lead pipes, supply a number of families in the neighbourhood; yet the degree of health, according to the number of inhabitants, is as good as it ever has been—the bills of mortality show as few deaths.

I have been a practising physician, in this town, for nearly fifty years. When I came here, the number of inhabitants was between sixteen and seventeen hundred—and the number has varied but little to this day. There has been an increase in the village, but

the outer parts of the town have lost, and portions have been added to other towns adjoining. Statistics show the average number of deaths, per year, for all this time, to be about twenty-six—varying some seasons, when epidemics have prevailed.

In 1820, when the lead pipes were first laid, and for several years afterwards, there was much solicitude felt by many, lest we should all be poisoned. Newspapers and other publications often brought frightful stories of the bad effects of water drawn through lead. The physicians of the place have been often called upon for their opinions on the subject—in fact, we have ourselves felt considerable anxiety respecting it. There are now two physicians here besides myself. But no case is known, in which disease has been produced by using water brought through lead pipes.

I am myself familiar with the effects of lead on the human system. Soon after I came to Amherst, I was called to visit, professionally, the family of a house-painter. I found some strange and painful neuralgic complaints; much resembling those named in the questions proposed by your committee. Colic, pains in the limbs and joints, partial paralysis, also appeared. Some of the family died from these diseases; the father died from a violent paralytic shock. I have witnessed other like cases among house-painters. Until late years, it should be remembered, painters ground and mixed their own colours.

The water, brought in our aqueduct, is very pure; it is good to drink—good for all domestic purposes—good for medicinal purposes —the best, I think, I ever used, except distilled water. Another proof of its purity is that, where the pipes have burst, as they frequently have, from the pressure of the water, there has been no appearance of corrosion on the inside the pipe—it was clean and smooth.

And now, my dear sir, after making as fair an investigation into this subject as is in my power, I am constrained to say that I have never seen nor heard of a single case of disease, in this place, which, I think, can fairly be attributed to any of the five points or questions put forth in the circular of your Committee.

I am, dear sir,
Respectfully yours,
(Signed) M. SPALDING.

Amherst, N. H., *Feb.* 18, 1852.

Reading, Pa., *Dec.* 19, 1851.

To Drs. Adams, Dana, and Dalton, Committee of the American Medical Association "On the Action of Water on Lead Pipes."

Gentlemen: To your circular on the above subject, I would reply that the city of Reading, containing 16,000 inhabitants, is situated at the foot of the South Mountain, on the edge of the great limestone belt that traverses the whole State from north-east to south-west. It has been supplied with spring-water since 1821, derived from the South Mountain, composed of a formation 1000

feet thick, consisting of a very compact, silicious rock. All the water from this formation, which is very abundant, is nearly as pure as distilled water. It is introduced in the ordinary way, through iron main-pipes, but nearly all the service pipes are lead.

I have practised medicine in this city for a period of twenty years, and can safely say that I have never noticed any facts that led me to suspect the prejudicial agency of lead, derived from this source, although my attention has been attracted to the subject for twelve or fifteen years.

I have conferred on the subject with my brother, Dr. Isaac Hiester, and Dr. Otto, both of whom practised in this city long before the introduction of the water, and have been in active practice ever since; and they both fully corroborate my own experience.

I have the honour to be your most obedient servant,

(Signed) JNO. P. HIESTER.

New Bedford, *March*, 1852.

Dr. Dalton—

Dear Sir: I received your circular of the 29th of January, and regret that I have not been able to answer it before. Having little, if anything *new* to aid you in your report, I have not considered it of much consequence.

There have been only three families in this city that have ever had any disease arising from water drawn through lead pipes; and in them it manifested its effects in the common form of lead colic. Two of the families were under the care of the late Dr. Alexander Read, of this city, and recovered, except a child three or four years old, in which the disease (as I now learn from the mother) probably terminated in marasmus, and proved mortal.

The other family was under my care. The father, a strong, athletic man, had a severe attack of lead colic, after drinking water, drawn through lead pipes, for four months. The water had not been used from the pipes for several months before they commenced using it this time. He had been suffering severely with colic pains several days before I was called. On examining him, his features had that peculiar shrunken appearance, together with blueness of the gums, &c., which we only meet with in lead diseases. On inquiry, I obtained the above history, which left no doubt as to the cause of disease. I treated him in the usual manner, with cathartics, opium, and calomel, bleeding both general and local *pro re nata;* he soon recovered, and has never had any attack since. Every member of the family had an attack of the disease before he recovered, and all happily recovered, and have never had any disease since that could be attributed to lead.

Painters formerly were peculiarly obnoxious to lead diseases, when they were in the practice of grinding and sifting the oxide of lead by hand. But I think it is seldom met with since this operation has been done by machinery. We have a number of men, in this city,

who, when apprentices to the painting business, and ground their lead, contracted the disease, and are now frequently suffering severe attacks of arthralgia; but I have not met with a case of encephalopathy that I supposed to be produced by lead alone.

There is one subject I will take the liberty to suggest to you; if it meets with your approbation, I will thank you to present it to the American Medical Association, and get a committee appointed to investigate the cause of anemia, complicated with the puerperal state, sore mouth, &c., and the most successful mode of treatment. It is a disease that is hardly recognized by any of our standard authors, and few of the journals of the day have noticed it. Dr. Hale, some twenty years ago, published an article of much merit at that time; since which, I have seen but little, but hope that some one will have something useful to offer us on the subject. It is a very formidable disease in its worst form, often consigning the mother of several children to an early grave. It rarely occurs in first pregnancies.

I am, with much respect, yours, truly,
(Signed) PAUL SPOONER.

N. B. This city contains 18,000 inhabitants; on inquiry of the plumbers, I find (in their opinion) that from one-half to five-eighths of the wells in this city have lead pipes in them, and the above cases are all that have ever occurred in this city. There is little doubt that water, in some places, contains substances that oxidize the lead, rendering it dangerous to use for domestic purposes, more than in others, and which can only be detected by chemical analysis; or that lead, of an inferior quality, has been used. All which is respectfully submitted by yours,

P. S.

Dr. Adams—

Dear Sir: In answer to your inquiries in relation to my experience as to diseases produced by drinking water which has passed through lead pipe, I answer briefly: After thirty years' experience, I am led to believe that, under certain circumstances, disease will certainly occur from its use; while, under other circumstances, which to me are inexplicable, it may be used freely, for an indefinite period, without producing any perceptible unfavourable results.

Three miles from my residence there is a factory village, the boarding-house of which has been supplied for more than a quarter of a century with water passing from eighty to a hundred rods through lead pipes, supplying the wants of about a hundred individuals; and although I have been a constant practitioner in that neighbourhood for that period, I have never known a single instance of disease produced by lead. In other parts of the town, the use of water, passing through lead pipe, has produced disease which could readily be traced to the absorption of lead into the system. I will refer to two cases. Miss P. suffered from colic, for three years, at

frequent intervals, from using water passing through lead pipe, without suspecting the cause. Being absent from home one year, drinking other water, she was entirely exempt from it for that time; on her return home, she again drank the water of the house, and again suffered severely from colic.

The cause being now ascertained, the use of the water discontinued, she was entirely free from it until more than three years after; while boarding in a house where lead pipe was used, she had another violent attack. Since then, for four years, she has, by abstaining from the cause, remained free from the disease.

The second case is as strongly marked. Mr. B., whose family consisted of himself, wife, and three children, in 1840, used water from a well about one hundred feet from his house, which passed through lead pipe; in June of that year, four of the five became dangerously sick from colic; the husband first, then the wife, and soon after, two of the children. The cases were distinctly marked, severe, and yielding with great difficulty to the usual remedies; on recovery, the use of the water was discontinued, and for the last eleven years, they have had no repetition of the disease.

What the peculiar properties of water, in different localities, are, by which it acts upon lead, I do not know; but that water, passing through lead pipe, in some places is perfectly innocuous, while in others it is poisonous, is certainly true; and it is worthy of our deepest study to ascertain all the facts in the case.

Yours, truly,

(Signed) JOSIAH BARTLETT.

Concord, Mass.

(B.)

Since the foregoing report was prepared, the *Manchester Guardian* of April 24, 1852, an English paper, has been received, from which we make the following extract. It proves the fallacy of the opinion, advanced by some chemical authorities, "that certain insoluble deposits are soon made upon the inner surface of lead pipe, by which the water transmitted through it becomes, in a very short time, safe to be used as a beverage, and for culinary purposes:"—

Poisoned Water.

To the Editor of the "Manchester Guardian:"—

I am sorry to trouble you again on this subject, but should feel obliged, if you would allow me space for a few remarks in reference to the action of water upon metallic lead. Mr. Pountney, whose communication appeared in last Saturday's *Guardian*, seems to have the common impression that water brought into contact with lead ceases, after a time, to exert any solvent influence upon it. There is no doubt that the new lead is much more readily acted upon by water than that which has been long exposed, in consequence of the metal becoming partially coated with the insoluble salts of lead, espe-

cially the sulphate, as you have remarked.—But that such coating is very partial, may be abundantly proved. A lady, who has been in the occupation of premises, situated within three hundred yards of the Royal Infirmary, for more than twenty years, has, during the last three years, been repeatedly under my treatment for painful dyspepsia, and occasional impairment of the senses. Her recovery was always protracted, and at no time satisfactory, until after a certain time she spent in the country or at the seaside. In January of this year, she experienced a recurrence of the old train of symptoms in an aggravated degree, with the addition of loss of sensation and impaired power of motion of the right hand, and the right leg and foot. I, on this occasion, for the first time, suspected the real cause of her indisposition. The water she had constantly used for four or five years past was found to contain lead. The mode of its impregnation is briefly as follows: There was, in the back premises, raised on a galley, a cistern about five feet in depth, and half that measure in diameter, made entirely of lead. This vessel had formerly been used for holding rain-water. But rain-water, in consequence of the immense quantity of soot carried down and mixed with it, having become useless, the pipe conducting it from the house top was directed into the common sewer, and the cistern thenceafter served for the reception of the town's water. This alteration was made about five years ago, since which time the lady and her domestics have never been in health until recently. The lady's niece, who occasionally resided with her, had repeatedly suffered loss of power of both hands, with other disturbances, on which account she had been removed to her parent's residence, where her health was restored.

Now the water supplied by the old Manchester Water-Works was exceedingly hard; Mr. Stone informs me that it possessed this quality to the amount, in chemical language, of sixteen degrees. When the finger was dipped into it and removed, the skin was scarcely moistened, but appeared as if that member had been previously coated with oil, so that the water left it almost dry. Water of this degree of hardness exerts less action on metallic lead than any other, and yet it had sufficient solvent power on the old lead cistern, notwithstanding that the cistern had been previously exposed to the action of a still more solvent fluid for ten or twelve years, to acquire poisonous qualities. Mr. Stone has examined old lead pipes which have for years been in use for conveying the water in question, and has found them deeply penetrated, and even perforated, from within outwards, with a multitude of holes made in process of time, by the corroding agency of water.

The water at present supplied to us by the corporation is much more pure than that derived from the old source; although it varies from time to time, in consequence, probably, of the old reservoir at Beswick being occasionally made use of. The latter ought to be dispensed with as soon as possible. The water we at present receive possesses about five degrees of hardness; but in the reservoirs at Woodhead, not more, as I am informed, than two or three degrees.

The purest waters exert the most powerful solvent action on lead. Distilled water, for instance, dissolves it freely; the next to this is rain-water; and the water supplied from the Woodhead reservoirs produces a speedy chemical change in virtue of the very quality for which it is most prized.

Water possessing more than sixteen degrees of hardness appears to become possessed of more solvent properties, and when this quality (hardness) exists in still higher degree, its chemical agency is nearly equal to that of pure water. This important fact, not hitherto published in books, is entirely due for its discovery, so far as I know, to Mr. Stone's investigations.

Water, also, which contains any considerable amount of hydrochloric salts, as that referred to in my former letter, acts very readily on lead.

I remain your obedient servant,

J. W.

(C.)

We cannot refrain from introducing here an extract from a letter of Dr. E. C. Bidwell, of Ohio. It contains facts and suggestions of much value.

"One advantage which I hope to result from the labours of your Committee, and the publication of your results, will be, to make the various forms of disease caused by lead to be more readily recognized by the profession, whatever the source of the poison, and even when no source is discoverable. This is certainly a desideratum, and it would seem to be not impracticable. We do not deny a case to be intermittent fever, because we do not know of the patient's exposure to miasmatic influences.

"The poison is wide-spread. It has manifold uses in the arts, and we are brought into contact with it in a hundred different forms in the every-day walks of life. It cannot, therefore, but be a frequent cause of disease. I have no doubt at all that, if the diseases that spring from it had been susceptible of accurate diagnosis years ago, hundreds of mysterious and mistreated cases would have been understood and cured. The 'bilious rheumatism' of some old doctors, for example, was always a mystery to me; now I think I understand it; at least I am sure I never had a case of the kind that was not caused by lead. I doubt not that, if we were more perfectly acquainted with the pathogmetic effects of lead—and of various other drugs, as well—many anomalous and inexplicable complications or sequelæ of diseases, in the treatment of which we have employed it, would become perfectly intelligible. The effect upon therapeutics of an improved diagnosis could not but be beneficial.

"With a brief allusion to another point, which may be worthy of your attention, I will close this communication. An infant at the breast had been for a short time with his mother, in a room where newly-painted articles were kept; the mother was often in the room, and

sometimes painted there; but the infant was never there but on the single occasion, and then did not touch the paint. A few days subsequent to this occasion, he was taken with characteristic symptoms of lead poisoning, the diagnostic *blue line on the gums* included. He continued to be affected with the disease, with remissions and relapses alternating, for a period of two months; after which, his recovery was progressive, although slow.

"The question arising here, upon which I confess my own mind laboured at the time, is, whether the single brief exposure of the child was sufficient to account for the repeated attacks which he suffered for so long a period; or were it not more probable that he 'sucked the poison with his mother's milk,' thus having it renewed day by day, the mother herself escaping the disease by the elimination of its cause through the lacteal secretion. This view is supported by the analogy of the 'milk sickness,' so destructive in some parts of this State. In this disease, in animals called the 'trembles,' milch-cows escape, while other animals not giving milk are trembling and falling, and dying around them; but those who use the milk of these apparently healthy cows, or its products, experience the disease in its utmost violence.

"Acting upon this view, in the above case, I early directed the child to be weaned; but after a brief trial, it was thought impracticable by the tender-hearted mother, and the attempt was abandoned.

"I then put her upon a course of medicine, as if herself affected with the disease; but am unable to say with certainty, how much effect this treatment had."

(D.)

Since the completion of this report, the following note has been received from Dr. Dana, a member of the Committee. Comment on its character and importance is unnecessary.

DEAR DOCTOR: I have been reading a thesis just published (1852) in Paris, by Dr. Guerard, Médecin de l'Hôtel Dieu—"Du Choix et de la Distribution des Eaux dans une Ville"—in which he (Dr. G.), p. 75, gives the following as the most remarkable fact of lead-poisoned water, related by M. Henri Gueneau de Mussy: "During many days, this clever practitioner misunderstood the character of the symptoms which he had observed." If so distinguished a pupil of the school of Paris has, for one moment, mistaken the true nature of like accidents, we may believe that lead-poisoning has, in a multitude of cases, been produced by lead reservoirs, and has run through its various stages, ending in death, without its cause ever having been suspected.

In 1848, after some months' residence at Claremont, many members of the family of Louis Philippe were attacked with symptoms of lead-poisoning. Violent colic, nausea, vomiting, with obstinate costiveness first appeared; later, jaundiced skin, nervous disturbances, simulating hysteria; the whole surface of the skin became so very morbidly sensitive, that the slightest touch produced in the sufferers

cries and tears. The vital force always diminishing, the progressive emaciation, the deep cachectic coloration of the skin, &c., caused the liveliest inquietude in M. Gueneau de Mussy, who, after vainly using purgatives, resorted to antispasmodics, to preparations of iron, sulphur, &c., from which better results were obtained. Other residents at the chateau were equally, but not so severely attacked.

Finally, out of 38 persons, 13 were poisoned, one-half of whom presented the *blue line* on the gums, and spots of the same colour on the mucous membrane of the mouth (*membrane buccale*). This line and these spots were, in many persons, the only trace of the action of poisoning matter (*matière toxique*). To what cause shall be attributed these symptoms?

The analysis of the water used at Claremont for domestic and culinary purposes showed 0.1544 grain (0.01 gramme) of metallic lead per quart (litre). But how shall we explain the presence of this lead in the water? Hear what M. Gueneau says about the changes in the apparatus for distributing the water: "When the *chateau* at Claremont was occupied by its new inhabitants, the water was conveyed from a natural cistern, situated near its source (distant 300 metres, about 975 feet), through lead pipes to a cistern of lead placed in the house. This natural cistern was encumbered with vegetable and animal remains. It was judged proper to replace the natural cistern by an iron cylinder, 6 feet in diameter, by 20 feet high, sunk 15 feet in the earth. To this cylinder was attached a lead pipe, which projected some inches within the cylinder; the cylinder was closed by an iron cover, pierced with holes to admit the air. Nothing is easier," continues M. Gueneau, "than to explain what has happened, under these circumstances. It is known, from the researches of Conillet, that *lead* is *positive* to iron, and especially to *cast-iron*. The contact of lead and iron favours the oxidation of the lead, which once transformed into hydrated oxide, will soon become carbonated, and dissolved by the excess of carbonic acid in the water."

As the quantity of lead daily dissolved was *inconsiderable*, the effects which it produced did not show themselves till after a somewhat prolonged use of the water.

The practical lesson which M. Gueneau draws from the facts above is this: "That contact, even mediately, between lead and other metals, especially iron, should be avoided in the construction of all reservoirs, destined for the conservation of water for domestic use."

How much better it would be to have said that lead should be avoided wherever alimentary water is to be conveyed or stored!

I consider the above case, in all its details, highly instructive, not only as it regards the insidious nature of lead attacks, but also as exemplifying the highly increased danger which arises from attaching lead pipes to iron mains.

I am very truly yours,

(Signed) SAML. L. DANA.