On the action of water upon lead pipes. Being a translation from the French of M. Belgrand. With introductory remarks / by W. Sedgwick Saunders.

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On the Action of Water upon Lead Pipes.

BEING A

TRANSLATION FROM THE FRENCH

OF

Marie-Françoise-Eugène 1810-78
M. BELGRAND,

WITH INTRODUCTORY REMARKS

BY

Chem
W. SEDGWICK SAUNDERS, M.D., F.S.A.,

MEDICAL OFFICER OF HEALTH AND PUBLIC ANALYST FOR THE CITY OF LONDON,

LATE PRESIDENT OF THE HUNTERIAN SOCIETY, &c.

Presented to

THE HONOURABLE THE COMMISSIONERS OF SEWERS,

November, 1881.

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LONDON:
CHARLES SKIPPER AND EAST, PRINTERS,
ST. DUNSTAN'S HILL, E.C.

At a Meeting of the Commissioners of Sewers of the City of London held at the Guildhall of the said City, on Tuesday, the 27th September, 1881.

EDWARD EYRE ASHBY, Esquire, in the Chair.

The Clerk laid before the Court a Letter from the Préfet of the Seine, with documents relating to the Water and Sewer Systems, Paris, Unhealthy Dwellings, and the action of Water on Lead Pipes.

Resolved and Ordered—

That the same be acknowledged with Thanks, and the request for Documents published by the Commission be complied with.

Resolved also—

That the Pamphlet relating to the action of Water on Leaden Pipes be referred to the Medical Officer of Health for consideration and translation, and be printed for the use of the Commissioners.

HENRY BLAKE,
Principal Clerk,

TO THE HONOURABLE THE COMMISSIONERS OF SEWERS OF THE CITY OF LONDON.

GENTLEMEN,

Agreeably to the instructions of your Honourable Court, dated the 27th September last, I present to you the following translation of the essay of M. Belgrand on the action of water on lead pipes.

In rendering the same into English I have endeavoured to convey the information it contains without strictly adhering to the exact verbiage of the author, a course found necessary owing to the many technicalities with which it abounds, and for which I have been unable to find a literal equivalent ; whilst it is, however, a perfectly *free* translation, the scientific details dealt with have been scrupulously reproduced.

The action of waters upon lead had been long recognised by chemists of all countries, and before

the appearance of M. Belgrand's brochure much had been written upon the subject, and the chemical conclusions enunciated by him anticipated by a general consensus of scientific opinion.

The purest waters, when in contact with air, seem to produce the speediest effects, but no change is observable when lead is brought into relation with *pure* water from which the air has been expelled by boiling ;—a powerful corrosive action goes on when the metal is exposed to the combined action of air and *pure* water. "The surface of the lead then "becomes oxidised, the water dissolves the oxide, "and this solution absorbs carbonic acid, when a "film of hydrated carbonate of lead is deposited in "silky scales. Another portion of oxide is formed, "which is dissolved by the water, and thus a rapid "corrosion of the metal ensues. This action is ma- "terially modified when various salts exist in the "water, and even when their quantity does not "exceed 3 or 4 grains in the gallon. The corrosion "is increased by the presence of chlorides and "nitrates, but diminished by sulphates, phosphates, "and carbonates, the oxide of lead being scarcely

" soluble in water containing these salts in solution."
—*(Professor Miller.)*

Water is said to have less effect upon lead when the metal is bright and new, than when it has become tarnished by exposure to the atmosphere, but in either case the action is much more rapid with pure waters, than with those containing foreign matters, salts, &c.

Many waters containing organic matter act upon lead, and it is probable that to this fact the well-known corrosive effect of alluvial deposits is due, when under these circumstances the metal becomes covered with a compact film of sub-oxide, which protects it from further injury.

Great divergence will be found in the writings of authors entitled to respect concerning the action on lead of waters containing free carbonic acid ; thus, Miller, Graham, Frankland, Hofman, and others, from whose works these introductory remarks are chiefly compiled, contend that carbonic acid protects the lead by forming with the lime salts

existing in most waters an insoluble crust of carbonate of lead in the pipe, whereas M. Langlois* attributes a great action on lead to the carbonic acid, but admits that carbonate of lead counteracts its effects.

Professor Parkes, however, reminds us that an excess of carbonic acid may dissolve this coating, since we know that water charged with this gas under pressure, as in aërated waters, will rapidly absorb lead, a fact which at once explains the occasional mischief produced by the incautious employment of leaden and composition pipes in the manufacture of artificial mineral waters and effervescing beverages.

Other substances in water, such as the organic acids of vegetables and fruit, and even sour milk, may have the same effect.

It has been authoritatively laid down, that "the presence of dissolved oxygen, and the "absence of more than three volumes of "carbonic acid in 100 volumes of water, are

* M. Langlois, Rec. de Mem. de Med. Mill., 1865.

"amongst the conditions necessary for the attack "upon lead."—(*Rivers Commission*, 1851.)

Some waters contain lead as a natural constituent; the supply to the town of Edinburgh, for instance, is said to be contaminated to the extent of $\frac{1}{140}$th of a grain to a gallon, a proportion which does not appear hurtful. Calvert found that from $\frac{1}{10}$th to $\frac{3}{10}$ths of a grain per gallon existed in some water at Manchester, and was the cause of much suffering. Again I may mention the well-known cases of poisoning amongst members of the ex Royal Family of France, at Claremont, where thirty-four per centum of those who drank the water were affected by $\frac{7}{10}$ths of a grain per gallon. In my own practice I have invariably condemned water in which lead existed to the extent of $\frac{1}{10}$th of a grain per gallon, and believe it would be safer to reject a sample containing even half this quantity, having regard to the fact that some persons are much more susceptible to its injurious effects than others.

In 1877, Mr. G. Bischof called attention to the fact that lead piping frequently contains antimony,

which adds sensibly to the danger of its use ; the same chemist also adverts to the reprehensible practice of plumbers using composition tubing in connection with water supplies for domestic purposes.

In substitution for lead I know of nothing better than wrought-iron pipes leading from slate or galvanised iron cisterns, where a constant service cannot be obtained.

In H. M. Navy the water tanks are not galvanised, but the interiors are occasionally lime-washed, it having been found that with galvanised pipes the water becomes impregnated with zinc, which may be seen as a white film floating on the surface.

It is true that water in passing through iron pipes becomes turbid by the presence of yellowish suspended matter, which is in fact a hydrated oxide of iron or rust, but this is not injurious to health and is at once removed by ordinary filtration.

Hard waters act less upon iron than soft waters. The sixth report of the Rivers Pollution Commission, 1874, pp. 221-222, contains some very valuable information respecting the best methods of protecting cast-iron pipes from corrosion.

I object to the lining of one metal with another, such as tin upon lead, as proposed by M. Belgrand, for two reasons, first, because when different metals are brought into contact a galvanic action is set up; second, because block tin pipes have been known to be eaten through by water in consequence of the presence of nitrates (De Chaumont).

I have the honour to be,

GENTLEMEN,

Your obedient Servant,

W. SEDGWICK SAUNDERS.

13, QUEEN STREET, CHEAPSIDE,
30th October, 1881.

INSTITUTE OF FRANCE.

ACADEMY OF SCIENCE.

Extract from the Transactions of the Academy of Science, Vol. 77, November, 1873.

THE ACTION OF WATER UPON LEAD PIPES.

By M. BELGRAND.

LEAD has been employed in the manufacture of conduit pipes ever since the distribution of water in towns was first established by the Romans, the first aqueduct, the Appian, according to Varro,* being constructed in the year of Rome 442.

From that period leaden pipes have been in constant use ; all the water services in the interior of ancient towns being made of that metal.

* Varro, *Marcus Terentius*, a learned writer at Rome, B.C. 116. W.S.S

Each consumer had his branch connected with the reservoir or basin of distribution common to all the inhabitants of a district, and leading to his dwelling.

The public fountains were supplied in the same manner. The pipes which united the private to the public water works were invariably made of lead. (See Frontin,† who gives dimensions of the leaden pipes laid down in Rome.)

This mode of circulation necessitated very long leaden water pipes, and was used in Paris until within the last few years ; it still exists in Rome, at Claremont-Ferrand, and in several other towns.

In the middle ages, and until the end of the 18th century, public supply pipes were made of lead, and many of this material were found in Paris some years since, dating from the time of Philip Augustus.

The employment of *Cast* pipes became general about 1782, at the time of the establishment of

† Frontinus, *Sextus Julius*, a Roman statesman and author, in the latter half of the first century, wrote a treatise " De Aquæductis," still extant. W.S.S.

Chaillot's works, and of the Gros-Caillou, by the Brothers Perier. From those remote times up to that period no danger whatever had been discovered in the use of lead. Neither Pliny, Frontin, nor any of the old historians, ever pointed out the slightest injurious effect traceable to it. It was the same in the middle ages, and in modern times.

Only within the last few years an attempt has been made to alarm the public by endeavouring to show that the use of lead pipes is dangerous ; the water, it is said, is impregnated with a small quantity of lead which creates a slow, but pernicious, action upon the health of the consumer. This year the war against lead (*" La guerre au Plomb"*), the name given to this crusade, has made great development and caused considerable uneasiness in the minds of Parisians.

It became therefore my duty to examine what foundation existed for these charges, and I have done so with the help of M. Felix Le Blanc, a distinguished Chemist and Gas-Examiner. M. Boudet was entrusted with a similar investigation for the Board of Health.

I must first clearly state the case and give the facts concerning the distribution of water, both public and private, in this City. The following statistics, dated 31st March, 1872, relate to the *public* services, viz. :—

	Mètres.
Cast iron pipes - - -	1,333,184
Tarred sheet iron pipes - -	63,126
Lead pipes (about) - - -	3,000
Total - - - -	1,399,310

It is thus apparent that the main pipes are out of the question, and that "La guerre au plomb" would be objectless if there not also existed a network of short connecting pipes of very small diameter, and which, almost without exception, are made of lead.

These small pipes connect the main pipes with the draw taps ; their network may be sub-divided thus :—

1.—Pipes connecting the Public Buildings	152
2.— Do. the Circuit - -	14

3.—Pipes connecting the Municipal Buildings :—		
* Water Posts, "à repoussoir" -	224	
Draw Wells - - - -	33	
Street Fountains - - -	456	
Hired Fountains - - -	26	
Bureaux de Stationnement -	155	
Various Municipal Establishments - - - -	167	
Religious Buildings - -	49	
Schools and Colleges - -	247	
	——	1,357
4.—Charitable Institutions - -		83
5.—Private Houses of Subscribers to the Town Supply - -		37,889
Total - - - -		39,495

Most of the leaden pipes, therefore, are chiefly employed to connect *private* houses with the main supply pipes.

In the foregoing calculation, those municipal supplies are omitted which are never used for drinking purposes, for example, monumental fountains, flushing pipes under the footways, corner posts, watering jets, fire plugs, steam pumps, and urinals, 8,277 in number, nor for

* Pressure fountains or ordinary pumps with handles. W.S.S.

watering the streets or the gardens, which are not less numerous.

The leaden branch-pipes connecting dwelling houses with the main supply number about 39,500, and their average length may be put at 40 mètres,* and their total length at 1,580,000 mètres.

In spite of the great complexity of this network, every drop of water drawn for domestic use runs through a very small length of lead pipe, say 5 mètres when drawn from the standpipes in the street, or at most 100 mètres when taken in a private house.

In the case of houses that are occupied, the longest period for the water to remain in the leaden pipes can be estimated thus :—

Houses having unlimited supply	9 hours during the night. from 5 to 10 min. during day.
Gauged supply	from 3 to 6 hours at the most.

As will be seen further on, the time the water is in contact with the interior surface of the pipe is too short for the lead to be attacked.

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* A mètre is 39·363 inches English. W.S.S.

I have already stated that in the net-work of main pipes there are about three kilomètres* of lead piping. These are from time to time removed, and on examination their interior surfaces are invariably found to be perfectly smooth and without any trace of corrosion.

I now exhibit two pieces to the Academy, one comes from the service pipe of the Faubourg Saint-Antoine, laid down in 1670, at the time when the pump of the Bridge of Notre Dame was erected ; it is therefore more than 200 years old, and in the interior the impression of grains of sand is still to be seen ; the other was taken up from a side street of Saint-Germain Market ; it is somewhat less old, but equally unblemished.

It may be added that the leaden pipes become firmly and rapidly coated with a thin crust† which prevents the water coming in contact with the lead. I place before the Academy for inspection, a piece of pipe upon which this is distinctly seen. I visited at the factory of

* A kilomètre is 1000 mètres. W.S.S. † Carbonate of lime. W.S.S.

M. Fortin Hermann, contractor for public works, the depôt for old and disused lead pipes, where numerous fragments of these branches are to be found, and did not find one piece in it which was not in this condition: the internal surface of the lead being perfectly smooth, and covered by a thin very adherent coating of carbonate of lime.

The harmlessness of leaden pipes appears to me proved by these facts, which explain why they are in use in all the towns of France, and in most European cities, without ever having given cause for complaint.

I have, however, by direct analysis, sought for lead in all waters with which Paris is supplied, and in these analyses M. Le Blanc was good enough to lend me his valuable aid. The experiments were first made upon the public waters of Paris drawn at the following points:—

1. Seine water at the Hôtel Dieu, from a lead branch 200 mètres long.
2. Seine water at No. 74, Avenue d'Orleans, lead branch of 100 mètres long.

3. D'Ourcy water at the Hospital des Récollets, pipe 130 mètres long.

4. Dhuis water at No. 40, Avenue de Clichy, pipe 20 mètres long, consumption of water per diem 250 litres.

5. Dhuis water at No. 25, Rue de Moscow, lead pipe 40 mètres long.

A sample bottle of 5 litres of each kind was sent to M. Le Blanc, who reported :—

" Sample received 16th August, 1873.

" Not any of these clear and colourless " waters give an appreciable coloration with " sulphuretted hydrogen ; not a trace of lead " is found in the residue obtained by evapora- " tion in a platinum capsule.

" The same remarks apply to the sample " received on September 1st and to that of " October 1st."

It must be concluded from this first series of experiments that the public waters of Paris, drawn at the extremity of the leaden branches, do not contain a trace of the metal when the house is inhabited,

that is to say, when the water does not remain in the pipes more than nine or ten hours.

M. Le Blanc has undertaken other experiments, by leaving the lead in water for a much longer period. I quote his own words :—

ON THE ACTION OF WATERS UPON LEAD.

Chemists have long known with what facility lead becomes oxidised when immersed in distilled water in contact with air. Very small white shiny crystals of the hydrated oxide of lead are very rapidly formed, their quantity augmenting until a copious sediment at the bottom of the vessel has formed; the same obtains with pure rain water.

On the contrary, water containing a given quantity of salts, principally from selenitic wells, does not attack the lead under the same conditions at all.

Such are the results of experiments made by Professors of Chemistry during the last 40 years in public lectures, and M. Dumas never omitted to place them before his class at the Sorbonne.

Chemists have often remarked upon the harmlessness of lead with regard to potable waters, circulating in pipes of this metal, because of the *saline* matters which preserve the metal from oxidation.

No doubt it would be difficult to give an explanation of these facts, but they seem of the same kind as those which have been

established with regard to iron, which can be preserved without oxidation in distilled water, even when aërated, if only a few drops of an alkali be added to it, whilst it is oxidised rapidly in pure aërated water. But it is curious to observe that by augmenting to a certain extent the proportion of alkali, oxidation can be facilitated.

It is well known how much the peculiarities pointed out by M. Gaymard in the case of the water-pipes at Grenoble, have occupied chemists during the last 40 years.

It becomes therefore of importance to ascertain whether the purest potable waters contain sufficient saline matter to preserve the lead from oxidation.

The following table shows that very pure water, such as from the wells of Grenelle, possessing much less saline matter than water from the Seine, has yet the power of preserving the lead from oxidation. The water in question shows from 8 to 10 degrees of hardness.

It will be seen that the waters marking even less than 1 degree of hardness still preserve this same quality. Indeed, rain water itself cannot attack lead, if it has not been collected with the greatest care, and after prolonged washing by the atmosphere by previous rain. However little rain water may indicate by re-agents the presence of the salts of lime, we find that it does not act sensibly upon lead. When rain water does not give any re-action with lime re-agents, it rapidly commences to attack the lead in the same way as distilled water does.

ACTION OF CHEMICALLY PURE LEAD ON DIFFERENT WATERS.

(The lead is immersed in water, and the liquid exposed to the air. About 25 grammes* of pure lead, and 250 cubic centimètres† of water are used.)

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* A gramme is equal to 15·438 grains troy.
† A cubic centimètre is equal to 0·39371, or nearly two-fifths of an English inch. W.S.S.

NATURE OF THE WATERS.	DATE OF IMMERSION.	OBSERVED RESULT.
Distilled Water - - - -	September, 27th	Considerable action. White Crystals of Hydrated Oxide of Lead formed.
Water from the Seine (1) - -	do.	No effect produced.
Water from the Dhuis (2) - -	do.	do.
Water from Grenelle Well (3) -	do.	do.
Water from Ourcq (4)- - -	do.	do.
Water from Arcueil (5) - -	do.	do.
Water from Belleville Well (6) -	do.	do.
Northern Spring, Près St. Gervais (7).	do.	do.
Water from Well at Passy - -	do.	do.
Water from the Reservoir of Gulf d'Enfer à Saint-Étienne (granite formation). Hardness 1°,44 (8).	October 8th.	do.
Water from the Reservoir of Settons (Morvan) River of Cure. Hardness 0°,96. (9).	do.	do.
Water of the Ourthe (Belgium) Devonian formation. Hardness 0°,96.	October 15th.	do.
Rain Water collected in Quay at Bethune.	October 8th.	No visible effect. Traces of Sulphate and of Lime.
Rain Water collected on the Reservoirs of Ménilmontant.	October 28th.	The corrosion of the Lead was evident at the end of 24 hours, and went on increasing. Deposit very abundant on November 5th.

(1.) At the mouth of the Aqueduct of Ménilmontant.
(2.) In the middle of the stream, near the supply for the Orleans Railway.
(3.) At the top of the well.
(4.) In the middle of the Inner Circle Station.
(5.) From the Aqueduct.
(6.) House, 19, Rue Fessart.
(7.) From near Mossins, behind Bastion 20.
(8.) This reservoir generally contains 1,600,000 cubic mètres of water.
(9.) This reservoir has a capacity of from 19 to 20 millions of cubic mètres.

NOTE.—The pipes encased in tin were not more attacked than the leaden town pipes. The well water of Grenelle was employed for comparative experiments,

Which salts are the most efficaceous, when present in minute quantities, in preventing oxidation of lead in contact with water? Salts of lime alone are unquestionably so, even in the smallest proportions; in the absence of lime other salts are capable of protecting lead, in quantities of 0·1 gramme per litre. Nevertheless after from 24 to 30 hours the water becomes faintly coloured by sulphuretted hydrogen; but this oxidation soon ceases. The following experiments were made to ascertain the particular influence of different salts.

Solutions were made with sulphate of soda, chloride of sodium, chloride of potassium, sulphate of magnesia, the strength of each solution being 0·1 gramme per litre. The lead was immersed in these for 24 hours, when the water became coloured by sulphuretted hydrogen, but the solvent action did not continue, and it may be said that the solutions in question are without notable action upon lead, for, at the end of 10 days, the re-agent did not produce any real precipitate. These experiments will be continued by varying the proportions.

We have, with M. Le Blanc, undertaken another series of experiments, by operating upon water under the most favourable conditions for its contamination, and have obtained some traces of lead in the residue left by evaporation. As soon as this further inquiry is terminated I will forward the results to the Academy.

Upon the whole there is absolutely no danger of poisoning from the use of water flowing through leaden pipes.

It would doubtless be very difficult to compel, as has been suggested, the Parisian houseowners to replace the 1,500 kilomètres of lead branches at present existing in their property, since it is found that the interior of these pipes are perfectly smooth, without a trace of injury, and coated with a thin crust of adherent deposit, which prevents the contact of the lead with the water.

I do not think that any other mode of distributing water can be recommended, even to nervous people ; the iron pipes so much used in London on account of their low price, are less suitable for Paris, first because the necessary joints and connecting pieces are not to be found in commerce, but especially as accidents from frost, more to be feared in Paris than in London, are more formidable with iron pipes than with lead.

Leaden pipes lined with tin have been lately recommended. These are very expensive, and possess the grave objection that in soldering the joints the inner tin casing (or lining) is melted,

and creates obstructions in the pipe. I have obviated this difficulty by causing the tin to be melted beforehand off those ends of the pipes intended to be soldered, for a length of 8 to 10 centimètres (three to four inches), in a sand bath heated to more than 227° C.,* the melting point of tin, and less than 330° C.,† the point at which lead fuses. It is true that a small surface of lead is left unprotected by this device, but, in my opinion, for so short a length as to be practically unimportant. One cannot, however, advise the employment of these, since they are too novel for us yet to know all the disadvantages which they may possess. In reality none of these pipes can have any effect whatever on the health of the public. The administration has therefore adopted the only sensible course in authorizing subscribers to use, at their own pleasure, and on their own responsibility, either the leaden pipes, or those of iron, cast or otherwise, or those in lead lined with tin; on the sole condition of giving to all pipes laid under the

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* 227 degrees Centigrade, equal 440·6 degrees Fahrenheit.

† 330 degrees Centigrade, equal 626 degrees Fahrenheit. W.S.S.

public roadway the thickness necessary to resist the pressure of the water.

End of M. Belgrand's *communication.*

At the same sitting of the Academy M. Dumas made the following communication :—

" M. Fordos has requested me to present to the " Academy the paper that will be read later.* " In complying with the desire of that learned " chemist, and quite accepting the results which " he announces as to the effects of prolonged " shaking of grains of lead† in contact with air and " water, and also the inferences which he draws with " regard to rinsing bottles, the Academy will allow " me to make some remarks upon the contact of " potable water with vessels or pipes of lead. I made " long ago in my public lectures the following " experiments. Five flasks being filled with grains " of lead, I poured some water into each.

" 1. Distilled water.
" 2. Rain water.
" 3. Water from the Seine.
" 4. Water from the Ourcq.
" 5. Well water.

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* See the Transactions of the Academy of Sciences of November 10th, 1873.
† Probably leaden shot. W.S.S.

"I showed by the action of sulphuretted hydrogen (H_2 S) that the water of the first flask gave evidence almost immediately of a trace of oxide of lead dissolved in it, while the flasks which contained water more or less charged with lime salts did not contain any.*"

"The rapidity with which distilled water takes up lead is surprising: the effect produced by even traces of lime salts in preventing this contamination is not less so. One cannot forbear comparing these facts with those which M. Schlœsing has observed with reference to the white clay which will remain indefinitely suspended in pure water, but which the very faintest trace of lime salts will precipitate."

"The properties of absolutely pure water are hardly yet known, and they differ, I dare say, more than is supposed, from those of ordinary water."

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* If one takes some water from the first rain which falls after a dry period, it is found charged with lime particles which the later rains, having traversed pure air, do not contain; according to the rain water chosen then, the effects may differ, still as a whole, the rain water of Paris is almost identical with the water of the Seine.

The following note of M. Chevreul has been published in the "*Compte rendu*" of the meeting of November 17th, 1873.

"Want of time having prevented me from inserting in the Minutes of the meeting of November 3rd, some observations in relation to the action of pure water on many metals which were suggested to me by the communications of M. Fordos and of M. Belgrand, I must ask the Academy kindly to allow the following observations to be inserted in to-day's Minutes."

I. OBSERVATIONS IN RELATION TO HYGIENE.

"In the '*Bulletin des Séances de la Société Centrale d'Agriculture de France*' (July 9th, 1873), in reference to a petition from M. de Laval to the Corporation of Paris, to do away with leaden pipes, I made the following remarks:—

"'Our Vice-President, M. Chevreul, will recollect 'the remarks which he made at the Gobelins, upon

'the action of distilled water on lead and zinc, 'an action which is not exerted by *hard* waters 'which contain certain salts in solutions.'"

"'He also will remember having told the 'Society that similar observations were made long 'before his own by M. Guyton de Morveau, 'who had noticed that pure waters acted not 'only upon lead but also upon zinc. It is to 'M. Guyton, added M. Chevreul, that the merit 'of the observation in question is due.'"

Furthermore, in the *Journal des Savants* (October, 1871, p. 488), one reads :—

"'It may not be inopportune to draw attention 'to a fact not sufficiently known to the public, 'namely, that rain waters alter leaden and zinc 'vessels more than waters containing salts in 'solution, well waters for example. The result 'of this is that *these latter waters may remain in 'a leaden vessel without attacking it, and without 'becoming poisonous, while rain waters, free from 'saline matters, dissolve oxide of lead and thus 'become poisonous.* This observation quoted from

'Guyton de Morveau is perfectly true. I have 'verified it at the time of my investigation on 'the waters of the Bièvre.' "

"If particular circumstances had not prevented me from going to the Gobelins to-day to seek the results of experiments dating back to 1836, and which I will lay before the Academy in due course, you could have seen the effect of distilled water, as compared with that of well water, upon a sheet of lead, and also a similar difference between iron and steel in distilled water, and the iron and steel in an alkaline liquid."

"I had occasion in 1844 to notice a fact relating to hygiene and to ordinary economy, which was, that in a great industrial establishment, the name of which it is unnecessary to give, they had invented a method of preparing calico with the sulphate of lead obtained in the preparation of the cotton weavers' dye, by the reaction of acetate of lead and alum. It happened that a Sèvres washer-woman, whose customers belonged especially to that part of Paris where the warehouses of dyed

linen goods are situated, was greatly astonished to see the linen which she had washed come out black and discoloured from her wash-tub. The explanation was that she used soap lees prepared with a mixture of soda, of potash, and of sulphide of lime, and that this at once caused the formation of black sulphide of lead with the sulphate of lead in the clothes. I have narrated this fact in the *Compte rendu* of the meeting of September 16th, 1844."

"In 1841 I was directed by the Minister of Marine to examine, conjointly with M. Lebas, whose name is so closely associated with that of the Luxor obelisk in the Place de la Concorde, several methods of purifying the water for use in the navy. Among these methods was included that of distilling sea water by means of the apparatus of a Nantes operative. We discovered the presence of copper, derived from the metal of the condenser, in the water thus distilled; and after having ascertained that a drinkable water could be obtained from a sample giving a reaction with sulphuretted hydrogen by passing the water through

a carbon filter, which, by capillary attraction, would take up the copper, we advised the authorities to instruct the doctor on board to have some stoppered flasks of one decilitre in capacity, containing solution of a sulphate and oak shavings, so as to obtain a re-agent capable of showing not only the presence of copper, but also that of lead ; because the soluble sulphate in the water is transformed, after a few days, into sulphide by the soluble oxidisable matter of the oak wood."

II.—OBSERVATIONS IN RELATION TO THE ARTS.

"I remind you that the presence of a copper salt in the tissues of wool, which is intended for example to be subjected to the action of steam after being printed, causes it to assume an orange colour, because the sulphur of the wool produces a coloured sulphide, under the influence of heat and moisture.[1] A brown or black sulphide will be produced if the tissue contain some salt of lead, as happened in 1844, when in the manufacture of some woollen tissues in Picardy,

(1.) *Compte rendu*.....,December 26th, 1837.

a weaver had used a gelatine which the maker had whitened with acetate of lead ; and thus the impregnation of the warp with this gelatine caused the tissues, after being printed and passed through steam, to become stained.[1]"

III.—OBSERVATIONS IN RELATION TO CHEMISTRY.

" In 1837[2] I called the attention of chemists to a fact to which I attach great importance ; it concerns the use of re-agents in chemistry."

" I recognised that all alkaline re-agents which were kept in flasks of white glass, in the manufacture of which, in order to give greater whiteness, fragments of leaden glass are largely used, contain from that source oxide of lead in solution. I thought it right, therefore, in the interests of science, to show the necessity of keeping the re-agents of which I speak in future always in vessels of green glass. It is here not only a

(1.) *Compte rendu*.....September 16th, 1844.
(2.) *Compte rendu*.....December 26th, 1837.

question solely of pure science, but also of toxicological analysis, and nobody will blame me for recommending an examination of the re-agents used, knowing that the experts chosen to perform such analysis always make what are called blank experiments in order to avoid all errors, and especially those which might be due to the re-agents employed."

"Since it is a scientific question, an important communication made at the last meeting on the influence of salts in causing the precipitation of white clay in suspension in water, encourages me to make the two following remarks:—

"The first is, that this communication proves the proposition that I have several times enunciated, and that quite recently, on the solvents. In fact, I have remarked that the moment a solvent takes up any substance in solution it becomes a different solvent from the original one; in other words, it can now dissolve bodies which it could not dissolve when in a state of purity, and this is the cause of one of the greatest difficulties of proximate organic analysis."

" The second is, that in the article, *Gold*, written for the *Dictionnaire des Sciences naturelles*, an article which appeared in 1825, in volume 36, I said, after speaking of a method of preparing the Purple of Cassius by the nitrate of proto-oxide of tin: 'I have several times noticed that the addition of 'a few drops of a solution of a neutral salt, such 'as sulphate of potash, at once brings about a 'deposit in a liquid which would have otherwise 'been several days without giving a precipitate.' "

CONCLUSION.

" After having heard the advice given by M. Belgrand in reference to the conveyance of spring waters through leaden pipes (*a*), I share his opinion as to the usefulness of leaden pipes on condition that a test is made in every case where it may be suspected that the water has remained too long in contact with the metal."

(*a*) The part of my paper to which Mr. Chevreul alludes has from lack of space not been printed in the *Comptes rendus* of November 10th, 1873. It will appear in the next communication.

I have received the following supplementary information on the distribution of water in different towns :—

Glasgow.—Enormous supply of water from Loch Katrine. Hardness from 3 to 5 degrees. In consequence of the purity of this water, contamination with lead was much apprehended; however, the house pipes were made of this metal, as in Paris, and experience has shown that no inconvenience has resulted.—(Information given by M. Mille, Inspector-General of Roads and Bridges.)

Brussels.—Water derived from chalky sources, like the water of the Vanne. The hardness probably varies from 18 to 20 degrees. According to M. Mauss, Inspector-General of Belgian Roads and Bridges, the public conduits are of cast-iron, the house pipes of lead. The harmlessness of the system is established, and yet a journal, published in Brussels, made a furious onslaught on the leaden pipes of Paris, forgetting those of its own town.

Lisbon.—Water of variable quality, in part very pure, showing only two or three degrees of hardness. The main services of cast-iron, house pipes of lead; the system was answering very well, till the "war against Lead" broke out and disturbed the public mind.—(Information given by M. Larcher, Engineer and Peer of Portugal.)

Avallon.—Water from granite formation. Standard of hardness from one to two degrees. Public conduits of cast-iron, house pipes of lead. This method of distribution in use since 1847, and, despite of the purity of the water, without any ill result. So-called centenarians are not rare in this pretty little town.

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