A NEW PROCESS

FOR

PURIFYING THE WATERS

SUPPLIED TO THE METROPOLIS

BY THE EXISTING WATER COMPANIES:

RENDERING EACH WATER MUCH SOFTER,

PREVENTING A FUR ON BOILING,

SEPARATING VEGETATING AND COLOURING MATTER,

DESTROYING NUMEROUS WATER-INSECTS,

AND

WITHDRAWING FROM SOLUTION

LARGE QUANTITIES OF SOLID MATTER,

NOT SEPARABLE BY MERE FILTRATION.

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A NEW PROCESS

FOR

PURIFYING WATER.

HER Majesty's Letters Patent for Invention have been granted "to Thomas Clark, Professor of Chemistry in Marischal College, University of Aberdeen, for a new mode of rendering certain waters (the water of the Thames being among the number) less impure and less hard, for the supply and use of manufactories, villages, towns and cities."

The process thus patented accomplishes more than has been so much as attempted by any of the recent numerous projects for procuring better water for the use of the metropolis. Suffice it in this view to mention, that from the water at present supplied to the several Water Companies, the process would withdraw solid matter that no mere filtration could separate, at the rate of a ton every hour that strikes. Luckily the process is one susceptible of being worked with great ease and regularity on the large scale.

The present pamphlet is intended to give so much general explanation as will afford an idea of the nature of the process, and of the advantages to be expected from its adoption.

Theory of the Process.

To understand the nature of the process, it will be necessary to advert, in a general way, to a few long-known chemical properties of the familiar substance chalk; for chalk at once forms the bulk of the chemical impurity that the process will separate from water, and is the material whence the ingredient for effecting the separation will be obtained.

In water, chalk is almost or altogether insoluble; but it may be rendered soluble by either of two processes of a very opposite kind. When burned, as in a kiln, chalk loses weight. If dry and pure, only nine ounces will remain out of a pound of sixteen ounces. These nine ounces will be soluble in water, but they will require not less than forty gallons of water for entire solution. Burnt chalk is called quick lime, and water holding quick lime in solution is called lime-water. The solution thus named is perfectly clear and colourless.

The seven ounces lost by a pound of chalk on being burned, consist of carbonic acid gas—that gas which, being dissolved under compression by water, forms what is called soda water.

The other mode of rendering chalk soluble in water is nearly the reverse. In the former mode, a pound of pure chalk comes to be soluble in water in consequence of losing seven ounces of carbonic acid. To dissolve in the second mode, not only must the pound of chalk not lose the seven ounces of carbonic acid that it contains, but it must combine with seven additional ounces of that acid. In such a state of combination, chalk exists in the waters of London—dissolved, invisible, and colourless, like salt in water. A pound of chalk, dissolved in 560 gallons of water by seven ounces of carbonic acid, would form a solution not sensibly different, in ordinary use, from the filtered water of the Thames, in the average state of that river. Chalk, which chemists call Carbonate of Lime, becomes what they call Bicarbonate of Lime, when it is dissolved in water by carbonic acid.

Any lime-water may be mixed with another, and any solution of bicarbonate of lime with another, without any change being produced: the clearness of the mixed solutions would be undisturbed. Not so, however, if lime-water be mixed with a solution of bicarbonate of lime: very soon a haziness appears; this deepens into a whiteness, and the mixture soon acquires the appearance of a well-mixed whitewash. When the white matter ceases to be produced, it subsides, and in process of time leaves the water above perfectly clear. The subsided matter is nothing but chalk.

What occurs in this operation will be understood, if we suppose that one pound of chalk, after being burned to nine ounces of quick lime, is dissolved, so as to form forty gallons of lime-water; that another pound is dissolved by seven ounces of extra-carbonic acid, so as to form 560 gallons of a solution of bicarbonate of lime; and that the two solutions are mixed, making up together 600 gallons. The nine ounces of quick lime from the pound of burnt chalk unites with the seven extra ounces of carbonic acid that hold the dissolved pound of chalk in solution. These nine ounces of caustic lime and seven ounces of carbonic acid form sixteen ounces, that is, one pound of chalk, which, being insoluble in water, becomes visible immediately on its being formed, at the same time that the other pound of chalk, being deprived of the extra seven ounces of carbonic acid that kept it in solution, reappears. Both pounds of chalk will be found at the bottom after subsidence. The 600 gallons of water will remain above, clear and colourless, without holding in solution any sensible quantity either of quick lime or of bicarbonate of lime.

This will give a sufficient idea of the theory of the patented process. Rules for discriminating the waters to which the process is applicable, and for ascertaining the proportion of lime or of lime-water that is proper for each, so as to make the foregoing theoretical principles available in practice, are to be found in the enrolled specification. (See Repertory of Patent Inventions for October 1841.)

ADVANTAGES OF THE PROCESS.

I. *The water will be much softened.*

The bicarbonate of lime dissolved in water *destroys* a proportional quantity of soap before it is possible to produce in the water a lather by the rubbing of soap; that is to say, before it is possible to have in the water undestroyed soap available for washing purposes. One hundred gallons of the waters of London supplied by the Companies take from twenty-four to thirty-two ounces of the best *curd-soap* of London in order to form a lather of such consistence as to remain all over the surface for five minutes. *So much does the new process alter these waters, in respect of hardness, that a similar lather may be produced in any of them by about one-third of the quantity of soap that is required by the same water before it is purified.* Indeed, the foreign hardening matter in the waters of the Companies is diminished by the purifying process in a still greater proportion. This is proved by a simple experiment. If a mixture be made in the proportion of one quart of any water supplied by the Companies to three quarts of distilled water, the mixture will be found, if carefully tried, to be no softer than what the supplied water becomes after purification by means of the patented process. Hence the process must remove three-fourths of the hardening matter.

The reason of the proportions of soap necessary for forming a permanent lather being a third, instead of a fourth, like the hardening matter, is this—that, of the soap employed in forming a lather, part is destroyed and part not. The part not destroyed is necessary to give sufficient consistence to the water to form lasting soap-bubbles, which, being aggregated, constitute a lather. Now the part of the soap destroyed must be very nearly proportional to the hardening matter present in the water; whereas the extra part of the soap not destroyed, but required to produce the consistence proper for a lather, must be nearly constant for any supposed bulk of water, be the water hard or soft. Thus, let the soap *destroyed* by one hundred gallons of London water be twenty-four ounces for the unpurified and six ounces for the purified, which is one-fourth part; if the extra quantity for each necessary to give the consistence proper for a lather be three ounces, then, in the forming of a lather, the quantity consumed will be twenty-four ounces added to three ounces, that is, twenty-seven ounces for the unpurified water, and six ounces added to three ounces, that is, nine ounces, for the purified, which is one-third part. Thus it is, that although the hardening matter may be a fourth, the soap consumed in the formation of a lather may prove to be a third.

To judge accurately of the saving in soap from the softening of water, the same principle must be extended to what may be called the washing duty that soap has to perform. For ordinary washing, such for instance as the washing of clothes, more soap is required than merely what would form a lather. Now this second extra quantity of soap will be likewise constant, with hard water as with soft. In the illustration already employed, where one hundred gallons of water, when unpurified, require for producing a lather twenty-seven ounces of soap, and when purified only nine ounces, we may further suppose, that nine ounces of soap additional to what would form a lather must be used in the washing of a certain parcel of clothes. In such a case, the unpurified water will consume twenty-seven ounces added to nine ounces, that is, thirty-six ounces of soap, while the purified will consume nine ounces added to nine ounces, that is, eighteen ounces, or one-half the quantity.

Even, however, when the utmost allowance is made on this principle, there would still be an exaggeration in the estimated saving on soap, did we not take into account the recently much-increased consumption of crystallized carbonate of soda, partly as a means of softening water and partly as a substitute for soap.

Whoever pays for water must pay also for soap and soda. No question, therefore, of cost or saving can be justly considered in regard to the one, apart from the other. Under this impression, the Patentee sought for the best information he could obtain as to the quantities of soap and soda consumed in the metropolis. The following estimate he regards as a sufficient approximation to the annual consumption :—

Soap, 12,000 tons at 50*l*. . . .	£600,000
Soda, 3000 tons at 10*l*.	30,000
	£630,000

Now, since the last Parliamentary Returns, made in 1834, show that the gross water-rent of the Metropolitan Companies was in that year about £270,000, we have scope for allowance for a subsequent increase, and yet may be within safe limits when we assume that the value of soap and soda consumed in the metropolis is double the gross water-rent. Hence, *if there be a saving of only ten per cent. on the value of the soap and soda consumed, it would correspond to a saving of twenty per cent. on the gross water-rent.*

It is not, however, alone in soap and soda that a saving arises from the use of soft water in washing. The labour in washing clothes is much increased by the use of hard water, and the wear and tear in consequence is probably a more expensive item than the additional soap. When the cost of wear and tear is kept in view, it may be doubted whether any real saving arises from the excessive use of soda that is now so common.

But, altogether apart from any saving in soap or soda that may arise to the inhabitants of the metropolis from the adoption of the patented process, there is the consideration of comfort—up to this time the almost unpurchaseable comfort of soft water in London. The purified water, after being used with soap in a washing basin, leaves on the surface only light soap-bubbles, instead of the white curd that surprises and offends the eye of any stranger accustomed only to soft water. When large quantities of water are used, such as are necessary for different sorts of baths, it is felt sensibly how much the hardness of water stands in the way of the effectual and comfortable washing of the person. The use of peculiar and expensive soaps never can compensate for hardness in water.

II. *The New Process will prevent Fur in Boiling.*

The matter deposited on boiling any water of the Companies consists chiefly of chalk. This deposit is occasioned by the bicarbonate of lime being gradually decomposed into carbonic acid and chalk. The carbonic acid escapes in the form of gas, and the chalk, being insoluble even in boiling water, subsides and mostly adheres to the boiler. The patented process removes the bicarbonate of lime. Consequently, no deposit of chalk can occur on boiling the purified water. No amount of previous filtration can prevent such deposit.

Certainly it is annoying, that the clearest water to be found in London cannot be boiled without becoming milky from the deposition of chalk. A protracted boiling, no doubt, will separate all the chalk, and soften the water. Most of the chalk will subside and form a crust on the bottom of the boiler. But the purified water, soft before it is heated, will not become like a thin white-wash by being boiled; nor will it, by a continuance of boiling, produce a filthy and obstinate incrustation. Small, however, are such advantages in domestic experience, compared with the relief that would be felt by the managers of the numerous manufactories employing steam-engines. The fur causes frequent cleaning out ot the boilers; and inasmuch as the engine is indispensable all the while that the general work of a manufactory is going on, such cleansings do come to be reserved for Sundays. The incrustations cause the boilers to be more frequently repaired—sometimes to need repair unexpectedly, at a time when the stopping of the engine may be next thing to stopping the whole manufactory. Nor is it, in a place like London, a slight consideration, that the risk of explosion from steam-boilers is increased wherever a fur is formed. More than anywhere, such risk should be avoided in the boilers of the high-pressure engines of railways. But the inconvenience of water depositing chalk on boiling is not confined to the boiler, or to the fur that adheres to the bottom. The portion of the chalk in powder kept afloat by the boiling often finds its way into the working parts of the machinery, so as, by rendering necessary the taking asunder of such parts for cleaning, to cause the stoppage of the engine —it may be of a whole manufactory.

III. *The New Process will separate Vegetating and Colouring Matter.*

Every person that has attended to the collection of water in considerable quantities for chemical or domestic purposes, must be aware that vegetation in the water during summer is frequently the most unmanageable of the impurities. When spring sets in, the waters of the Companies, if put into any large glass vessel so as to be readily seen, may be observed slowly to deposit a vegetation on the glass. Side by side, in similar vessels, this appearance will not occur in the same water after purification by the patented process. The reason is probably twofold; first, the lime-water, which exists in the mixture for a short time as lime-water, may destroy the germs of vegetation; second, the chalk as it forms has a cleansing effect on water, from the property it then possesses of incorporating itself with diffused mud or colouring matter in the water. Certain is it, at least, that from water containing such matter, chalk falls not in its natural white, but of a dirty appearance; and certain is it, that the water, after the chalk has fully deposited, is more clear and free from colour than it was before, or than it could be rendered by mere filtration. The deposition of diffused mud by subsidence will not only be much accelerated by the new process, but be rendered much more effectual.

Vegetating matter is an injurious impurity of the water supplied to the metropolis by the Companies, and it is increased by the system, adopted by most of them, of prolonged exposure in reservoirs for the purpose of subsidence. Such impurity renders their waters inferior to the spring-waters; it imparts an offensive taste; it affords nourishment to water-insects, and encourages their propagation.

IV. *The New Process will destroy Water-Insects.*

The insects that abound in the waters supplied to the inhabitants of the metropolis as a drink and for cooking, constitute a serious objection to those waters, not only for the disgust that such creatures must excite, but for the state of pollution implied in the single fact of their presence. It happened to the Patentee, early in the year 1841 to take from the water-pipe of a public hospital in town a quart of water, containing several scores of live insects visible to the naked eye. On inquiry, this appeared to be the same water as was supplied to the patients for drink. On the day before, the cistern, it was said, had been further drawn off than usual, and a larger supply of water had in consequence been received on the same day. Thus far, the occurrence of so many insects was accidental; but, with a good eye, it is not difficult to discover the creatures alluded to in the water as it flows from any of the pipes. In June 1843, the Patentee counted, with his naked eye, at the rate of between 450 and 480 of these creatures per gallon, in water that came from the kitchen-pipe of an eminent physician in town, who, from the circumstance of his using this water at his own table after being filtered, was by no means careless as to the quality of water supplied for the use of his family. In the patented process, the lime-water exists long enough, as lime-water, to destroy the most of the insects. This agent, by also arresting vegetation in the water, will probably cause these offensive creatures totally to disappear.

GENERAL OBSERVATIONS.

I. *Quantity of Water supplied to the Metropolis.*

In the several estimates that follow, the quantity of water at present required daily for the use of the inhabitants of the metropolis is assumed at forty millions of imperial gallons. We may form some idea of this bulk, if we conceive the supply of one day to be contained in a reservoir of a square form, each side being two hundred feet. The depth of the water would be one hundred and sixty feet. The quantity in demand is every year increasing.

II. *Large Quantity of Solid Matter withdrawn from solution by the New Process.*

The weight of chalk separated by the patented process from the whole waters of the several Companies would be about TWENTY-FOUR TONS A DAY, OR NINE THOUSAND TONS A YEAR. Here the weight stated refers to *matter such as no mere filtration can separate*, and it does not include any of the chalk that has for its basis the lime added to the water in the form of lime-water. Taking both together, the chalk that falls down would amount to Fifty-five Tons a day, or Twenty thousand Tons a year.

III. *Cost of the Purifying Material.*

As far as the Patentee has been able to ascertain, the cost of the burnt chalk required for all the Water Companies would be Ten Pounds a day. Against this cost, may come to be deducted the value of the fifty-five tons a day of deposited chalk, which cannot but be available for some useful purposes. Being burned, it would afford lime of improved quality for mortar, and, without being burned, it would answer as an ingredient of compost manures for clay soils. At the least, the expense of the burnt chalk would be reduced to the cost of burning.

IV. *Cost of the New Process compared with known Processes for effecting the same Objects.*

That it may be understood how the patented process comes to make the purification of water on the large scale practicable and eligible, a glance may be taken at the processes previously known for effecting the same ends. These were three:—

1st, *Boiling.* If the forty millions of gallons of water necessary for the supply of each day, were to be heated until it all boiled, and were afterwards to be kept boiling for two hours, the water would be brought into almost exactly the same state of purity as by the patented process.

2nd, *Distillation.* If the whole forty millions of gallons were distilled each day, the water would be purer than it could be rendered by the patented process; but if only thirty millions of it were distilled, and were, after distillation, mixed with the remaining ten millions, the mixture would correspond in softness with the purified water.

In regard to either of these processes, it were idle to enter upon calculations of cost. On the scale required, both are manifestly impracticable.

The third known process is the throwing down of chalk from solution in the water by means of *Carbonate of Soda.* On the small scale, this process is practised in preparing water for washing. If applied to all the water supplied to the metropolis, the experiments of the Patentee would show that the quantity of the material required for effecting a separation of the same quantity of chalk would be as much as would cost Eight Hundred Pounds a day, instead of Ten Pounds, as required by the patented process. *The difference is ninety-eight and three-quarters per cent.* When a process of chemical purification is invented, such as requires, in cost of material, only one and a quarter per cent. of what the most practicable of the known processes requires, it may be easily understood how the chemical purification of water should become practicable on the large scale—and expedient as well as practicable.

V. *The new Process is remarkable, as a chemical process, for merely withdrawing matter from solution in water—imparting none.*

When bicarbonate of lime is decomposed by carbonate of soda, which is the usual material employed, chalk falls down; but then bicarbonate of soda is formed, and is left in solution; in short, we merely *replace* bicarbonate of lime by bicarbonate of soda. Such a replacing of one compound in solution by another new-formed compound left in solution is the most ordinary mode of separation by chemical action on solutions. But, in the patented process no such new-formed compound is left in solution; for the caustic lime in the lime-water all falls down as a component part of chalk, along with other chalk from the bicarbonate of lime. This character of the patented process is as fortunate as it is rare in chemical processes.

VI. *The new Process compared with the late Mr. Telford's Project.*

When this eminent engineer made in 1834, at the request of Government, a Report on the best mode of obtaining pure water for the metropolis, he recommended that certain river-waters should be brought from a distance. The estimated cost was about £1,200,000. But so far as the estimate went, it was only for changing the source of supply to certain of the Companies, who, taken together, did not then supply so much as a half of what the metropolis received. *The water obtained after this outlay would have been little if at all better than what is now supplied. It would not have been softer; it would still deposit a fur; it would not be free from vegetation; it would have contained insects.* It is a triumph of chemical art over mechanical, that, by bringing into collision well-known chemical properties of chalk, itself the largest impurity, water free from this impurity and from all these defects can be obtained from sources at hand—water of a degree of purity such as the Patentee has not been able to obtain or hear of within a circle around London of more than thirty miles' distance—and, not only at hand and purer than money could command by mechanical means, but in a copiousness of supply that must be as exhaustless as the Thames.

Marischal College,
Aberdeen, January 5th, 1844.

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