

Minutes of evidence before the Judicial Committee of Her Majesty's Most Honourable Privy Council in the matter of Spencer's patent prolongation for the purification of water, June 13th, 1871.

Contributors

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Royal College of Surgeons of England

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MINUTES OF EVIDENCE

BEFORE THE JUDICIAL COMMITTEE

OF

HER MAJESTY'S MOST HONOURABLE PRIVY COUNCIL,

IN THE MATTER OF

SPENCER'S PATENT PROLONGATION

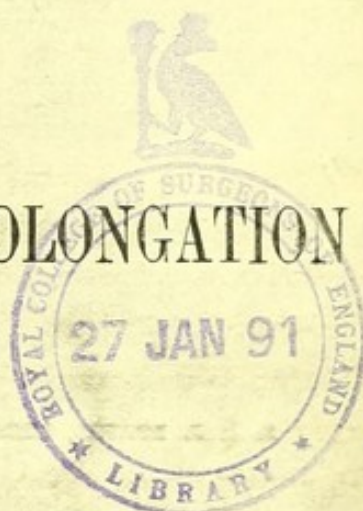
FOR THE

PURIFICATION OF WATER.

JUNE 13th, 1871.

LONDON.

—
1871.



LONDON:
S. & J. BRAWN, PRINTERS, PRINCES STREET, LITTLE QUEEN STREET,
HOLBORN, W.C.

PREFATORY.

THE object in printing the following evidence is not so much to afford a succinct account of the discovery of this the Natural mode of purifying water, as it is to give reliable testimony of its practical results for so many years in purifying the two remarkable waters supplied to Southport and to Wakefield, and this without any diminishment in the energy of the Magnetic Material employed. Witnesses were ready to give similar evidence as to the purification of other waters, but it was deemed that these instances would amply guarantee the purification of all intermediate qualities.

It can hardly be too often repeated that nature appears to have no mode of purifying water, other than that exercised by the ferruginous medium set forth in the following evidence. Though it is true that oxide of iron pervades, more or less, every stratification on the face of the earth, yet it is not all found in that state which is now shown to be the one fitted to purify. At the same time, the fact has been overlooked, that all soils contain some minute portion of magnetic oxide, without which, the water of every river would be unbearably foul and pestilential, from the accumulation of organic matter, which this oxide destroys.

The water of rivers flowing in stratifications where this purifying oxide abounds, is always relatively pure, and the country healthy. No better instance can be adduced than that of the two Niles. On the banks of the Blue or Abyssinian branches, including the Atbara, where magnetic oxide is plentiful—the water is pure—and zymotic disease hardly known. In regard to the White Nile on the other hand, which flows through a land containing little iron, and with scarcely a trace of it magnetic, the country is notably unhealthy and the water so surcharged with organic matter as

to render its exhalations pentilential at most seasons, whilst the few inhabitants on its banks are sickly—and demoralized.

Whilst admiring the water purified by this process, many find it difficult to understand on what principle the change is brought about, and this, too, without any retention of the impure matter in the filtering medium itself. Nor is the difficulty always solved by stating, in the language of modern chemistry, that it is effected by—“catalytic action.” In reporting on the invention in its early stage, to the Corporation of Liverpool, Professor CLARK, to explain catalytic action as exercised by the magnetic material, says, that it “almost reminds us of a *moral influence*, by which the mere presence of one substance causes action in another, without itself being acted on.” Such is substantially its nature, for though the magnetic body is not acted on itself, yet it causes the organic matter within its influence to be consumed, just as proximity to a magnet induces polarity in steel. Magnetic oxide, in like manner, polarises the free oxygen in water, by which this gas is changed into OZONE, a body known to purify the atmosphere, though not previously suspected of playing a similar part in water. This ozonising property of the oxide was fully shown in the experiments made before the Jury of the Exhibition of 1862, and is referred to in its Report, which states that:—“The indications of ozone are very abundant in these filters.”

The evidence as to expenditure, profits, &c., is omitted, as being without public interest, though all these details were brought forward in the course of the proceedings.

Some foot notes are added to elucidate parts of the evidence that could not be entered on consistently with the time of the Court.

EUSTON SQUARE,

London, August, 1871.

Minutes of Evidence before the Meeting

OF THE

JUDICIAL COMMITTEE

OF

HER MAJESTY'S MOST HONOURABLE PRIVY COUNCIL,

AT THE

COUNCIL OFFICE, WHITEHALL, ON TUESDAY, 13th JUNE, 1871.

Present:

THE RIGHT HON. LORD JUSTICE JAMES.

THE RIGHT HON. LORD JUSTICE MELLISH.

THE RIGHT HON. THE JUDGE OF THE ADMIRALTY COURT

THE RIGHT HON. SIR LAWRENCE PEEL.

MR. WEBSTER, Q.C., AND MR. ASTON,

Appeared as Counsel for the Petitioner.

MR. ARCHIBALD APPEARED ON BEHALF OF THE CROWN.

MR. WEBSTER opened the case for the Petitioner.

MR. ARTHUR P. BOWER (the Solicitor for the Petitioner) was sworn—and examined by MR. ASTON—as to the LETTERS PATENT—the due certification of the SPECIFICATION—and, produced copies of the newspapers, with the usual advertisements—as to the presentation of the petition—and the day of hearing.

MR. THOMAS SPENCER called in and sworn.

Examined by—Mr. Aston.

Q. You are the Petitioner in this Case?

A. I am.

Q. I believe you are a Consulting and Analytical Chemist residing at 32, Euston Square, London?

A. I am—and practise the branch of Engineering connected with the construction of filter beds, on the system I have introduced for purifying water—both as to its mechanical, and chemical purification. Among others, the large filter beds, for the supply of

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Calcutta from the Hoogley, are constructed from the plans I furnished to the Municipality of Calcutta.*

Q. You are a Fellow of the Chemical, and of the Royal Microscopical, and other learned Societies?

A. I am.

Q. I believe that formerly you resided in Liverpool?

A. I did.

Q. And you there contributed very greatly to those inventions now in general use for depositing metals by electricity and galvanism?

A. I did so entirely. The branch of science, now known as Electro-metallurgy, or "Electro-type," originated with me. It includes electro-plating, depositing and casting metals by electricity. When my first experiments were made the galvanic battery had not gone beyond the chemical laboratory—for any practical purpose.

Q. I believe you subsequently gave considerable attention to the subject of purification of water, and the means to be employed for effecting that end?

A. Yes, in 1846. I was then engaged by the Corporation of Liverpool to investigate and report as to the most available sources for a fresh supply of water to that town—and, as to the quality and probable duration of the supply it then had. In this duty I was employed conjointly with the late Dr. Buckland, Sir Henry de la Bêche, Professor Ansted, and Dr. Playfair. Each was directed to report separately, from the same instructions. The present supply to Liverpool is greatly in accordance with the recommendations of these Reports.

Q. I believe, that previously to 1846, you were engaged in researches for improving water supply, and ascertaining the various qualities of water?

A. Yes. The 1846 report was for the Corporation of Liverpool, but I had previously, rendered reports for the supply of other towns, all of which led me to observe the gradual deterioration of

* Referring to the above works the Calcutta correspondent of the *Times* of July 17, 1871, says:—"Dr. Macnamara, chemical adviser to this Municipality, states, 'That cholera has greatly decreased in Calcutta since the completion of the new water works, though even yet the use of the water is far from general.' As yet a part only of Mr. Spencer's plans are carried out, so that this water is only partially purified, even now. The cost of constructing mechanical filter beds on these plans is *less than one half* that of those constructed by the ordinary mode, whilst their superior efficiency is beyond all question, in thoroughly intercepting all suspended matters.

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water, which I could scarcely fail to see was a consequence of increasing manufactures, and the improvement of land—for, everything termed improvement of land, commences by its drainage, which means taking to the nearest river, and thence to the sea, the water, which would otherwise percolate through the soil to form springs, or feed the wells by which most towns were formerly supplied with relatively pure water.

Q. Then I may take it that from 1846 to the present time, your attention has been given to a great extent, to the purification of water, and the means to be adopted for effecting the same?

A. Yes. I may say, almost wholly so.

Q. You have ever since in fact made it your study?

A. Yes, I have made it an especial study, and have had considerable experience in connection therewith. There are few large towns in this country, for which I have not been professionally engaged, as to the water supply, and also for several abroad.

Q. Prior to the completion of the invention for which you took out the Patent which is the subject of this Petition, was your attention called to the different qualities of water which were found in different districts?

A. Yes, that is so. Finding that the spring water of some districts was much purer than the spring water of others, whilst the circumstances on the surface, from which the impurity of water arises, were very nearly equal, and this being confirmed by the results of analyses, showing great difference in the chemical purity of each water, I was thereby led to believe, that nature had some power of purification (apart from mere straining), in one district, which did not exist in others, the principle of which was unknown to chemists.

Q. That is to say from finding it pure in some districts, and not very pure in others, whilst the circumstances of the surface were in each case nearly alike?

A. Precisely so, it being much purer in some districts than in others, whilst the impurities on the surface were equal, led me to seek for the cause of the discrepancy—which ultimately revealed itself, but after a pretty long search.

Q. I believe that after a chemical examination of most substratifications, you attributed this difference to the presence of iron in them, in a particular condition?

A. Yes, but it was only after a good deal of investigation that I arrived at this conclusion. It was after getting specimens of the substratification from different districts where the spring water

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was very pure, and from others where it was less so, and analysing them and the water—and then taking each constituent separately, such as silica, and clay slate for example, in certain states of induration, and also broken pieces of trap rocks, and basalt and filtering impure water through them, and then ascertaining the effect produced in each case, that I ultimately concluded oxide of iron was the natural agent of purification. I was afterwards led to abandon this conclusion, temporarily, on finding that in the South Lancashire districts, where we have nearly all new red sand stone full of iron, the spring water was more impure than in districts where iron was apparently less abundant.

Q. Just answer this question please. Is it not a fact that you eventually discovered that the protoxide of iron was the oxide which produced the most beneficial effect upon the water through which it passed, as compared with the per-oxide?

A. I was about to state that in the districts where per-oxide of iron abounds, I found the spring water the most impure—and again, where the spring water was the purest, as in the Malvern district, I found that there was apparently less iron—and so, on seeing there was more iron in the sand stone where the water was most impure, I was led to conclude that, after all, the cause could not be due to oxide of iron.

Lord Justice James—Did you ultimately come to that conclusion?

A. No, my Lord. Ultimately I came back to my original conclusion that it was iron, but only after ascertaining, by very careful analyses, that in the purer water districts the oxide existed in a peculiar state of oxidation—magnetic in fact; but the knowledge of this difference did not arise in the earlier stages of the investigation, as all soil oxide was supposed to be non-magnetic.

Mr. Aston—And was that peculiar state the protoxide?

A. Yes, that oxide popularly known as the magnetic oxide.

Q. That is to say the proportion of oxygen being in it smaller than in the per-oxide?

A. Precisely so, though it did not appear so at first.

Q. In prosecuting these researches did you also analyse water obtained from foreign districts, as from the Nile for instance?

A. Yes, that was so. Through the engineers of my friend the late Robert Stephenson, whilst constructing the Cairo railway, I obtained specimens of Nile water, and Egyptian soil, and by the kindness of the late Captain Sir William Peel, then travelling in Nubia, I had specimens of the water of both branches of the Nile, and of the soil of Nubia, above the

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inundation, which greatly strengthened my belief as to the natural purifying power of magnetic oxide. I found for example from 14 to 16 per cent of magnetic oxide of iron in most of the specimens of Egyptian soil, and which, beyond doubt, was brought down by the Nile from Abyssinia, and due to the ever decomposing basalt of that country—and from which arises the great purity of the Nile water, as well as the healthfulness of the soil of Egypt proper.

Q. Then did those researches into the water and the soil of Egypt confirm the results which you obtained from your researches in England?

A. They did, very much, especially the oxide in the soil.

Q. And that satisfied you that the protoxide of iron was really the material which you should endeavour to obtain in a practical form?

A. It did, conjointly with experiments I had made on other soils, and water, from basaltic, or trap-rock districts, where the oxide of iron belonging to the soil is chiefly magnetic.

Q. Were you in the first instance able to obtain the protoxide in a useful form?

A. On concluding that protoxide of iron was the purifying agent employed by Nature, I believed that if it could be had cheaply my labours would terminate. So I procured some native magnetic oxide in semi-crystals as being easiest had in an isolated form.

Q. Did these crystals answer—did the protoxide in this form answer your purpose?

A. It certainly did not, and my disappointment was great, on finding it exercise scarcely any purifying power on water. That is in the crystalline or native form—as found in some iron mines.

Q. You then found it would be necessary to produce a form of protoxide of iron better fitted for your purpose—that is so is it not?

A. Yes. But it led me to give the subject up for some 12 months, until it struck me that my want of success might be due to the absence of pores in the crystalline oxide formerly tried.

Q. Having discovered that the absence of porosity in the crystallized oxide prevented it from being useful, what did you do in order to obtain the oxide in another condition?

A. I thought of spathose iron ore, one not found very plentifully in this country, but, obtaining some cabinet specimens, I drove off its carbonic acid by moderate heat, in the manner the same acid is driven off limestone in the ordinary process, by which

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means pores were left throughout its mass by reason of the departure of the carbonic acid. In short this gave me a black spongy oxide, and one exceedingly magnetic.

Q. That, I take it is as far as you were able to obtain it, answered your purpose?

A. I found at first it answered the purpose very well.

Q. Having ascertained this, did you find that there were difficulties in your way, which prevented your obtaining the spathose ore in sufficient quantities?

A. Yes, besides which, the oxide from this source was friable—and so became too easily reduced to fine powder, which in practice greatly retarded filtration through it.

Q. Were you then obliged to direct your attention to finding some other source of supply?

A. Yes.

Q. What other source did you then have recourse to, to obtain the porous magnetic oxide?

A. I knew that in Cumberland there was an unlimited supply of the purest iron ore in the world, but the most difficult to reduce into metallic iron. It could not be practically smelted by any heat unless other, but poorer ores were smelted along with it. Though I never lost sight of it, yet the acknowledged difficulty of dealing with it deterred me from attempting to make it available at first.

Q. What ore are you now speaking of?

A. The hematite ore, such as is found in Cumberland.

Q. That is a peroxide is it not?

A. It is a peroxide. At length, reckoning a little on the experience I had acquired in driving off the gaseous acid from the spathose ore, it struck me that if I could drive off only a portion of its oxygen from the hematite, it would leave the rest magnetic, and porous—in which, after resorting to several expedients, I ultimately succeeded.

Q. I believe it was necessary to calcine it in presence of carbonaceous matter, was it not?

A. Yes, that was so.

Q. Having completed your researches, and ascertained that you could drive off the excess of oxygen from the hematite ore, did you then mix it with carbonaceous matter, and produce a porous magnetic substance, on the scale you desired?

A. I did. Relying upon the chemical principle that decomposition is not effected unless, as a rule, another body is present, to take up the one we want to get rid of, and knowing that carbon and

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oxygen have an affinity for each other, I put charcoal in mixture with small pieces of hematite into a retort, and kept it at a dull red heat for 24 hours, by which means was obtained the porous oxide I required—carbonic oxide being eliminated.

Q. I believe that these researches were practically completed by about the year 1857, when you applied for your patent?

A. They were. In their course I had previously tried several rocky substances containing protoxide, and several species of iron refuse, but ultimately preferred ore treated as I describe.

Q. Have you a copy of your specification. I believe you have therein given a description of the various materials which you employ, and which partially answer?

A. Yes, I have.

Q. In it you refer to, among other things which contain iron oxide, the use of the oxide prepared from the hematite ore as being the best?

A. Yes, though other ores will do, I say, that available oxide for the same purpose is also obtained by calcining the well-known hematite ore. This operation being best performed by previously reducing the ore to a granular state, and mixing it with carbonaceous matter, such as coke or charcoal, and when calcined sufficiently it becomes magnetic. By a similar process of calcination several other ferruginous substances can be made available.

Q. At that time then you had your invention in the condition which was fit for being practically used?

A. I had at the time I obtained the patent.

Q. You had I think some subsequent improvements?

A. Yes, but they were chiefly in regard to the application of the magnetic substance similarly prepared, for other uses; and for some mechanical improvements in filtration also.

Q. As soon as you obtained your patent did you take steps to bring the invention before the public?

A. I did. The first was to lay it before the British Association for the Advancement of Science, at its meeting in 1859 at Aberdeen. I there read a paper before the chemical section of this body, over which Professor Playfair presided. Dr. Faraday, and other eminent members were present.

Q. Then you brought it for discussion before the meeting on that occasion?

A. That was my object in reading the paper.

Q. I need not ask whether on this same occasion you explained the benefits you anticipated to arise from the application of your invention?

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A. Yes, and detailed the experiments which led to its discovery, and repeated several of them. I also explained the theoretical principles by which the purifying action is constantly operating in nature. The paper occupied the better part of the day.

Q. Will you tell their Lordships, as shortly as you can, what are the special benefits which are derived from the use of this porous magnetic oxide in the condition in which you use it?

A. In answering your question, it will be necessary to state in the first place, that previously to this invention, it was a universally recognized axiom among chemists and engineers, that organic matter in solution, could not be removed from water by any practical means of filtration.*

Q. And I believe that the removal of organic matter held, as it is, in solution, is one of the objects which it is necessary to attain in order to have pure water?

A. Yes, it is the primary object. In speaking of impure water, or its degree of impurity, we generally speak as to its relative quantity of organic matter, which comprises its most dangerous source of disease, because this impurity is invisible.

Q. I believe there is little difficulty in removing matters which are held in suspension in water, such as are visible to the eye?

A. By well conducted straining, or mechanical filtration, there is no great difficulty in getting rid of what we see.

Lord Justice James—You may assume that.

Mr. Aston (to the witness) And the difficulty is to remove the organic matter held in solution which is not seen?

A. That was the great difficulty, previously to the introduction of this invention. It removes other deleterious matters incident to water. For example, sulphuretted hydrogen which imparts to water its well-known offensive odour. This it removes with great rapidity and certainty. It also oxidises the deleterious hydro-carbon gases which arise from the decomposition of vegetable matters in water. It abstracts iron from water, as at Southport, which will be spoken to by the next witness. It oxidises the nitrogenous gases which arise from the decomposition of animal matters, by which they are converted into harmless—or indeed beneficial—nitrites, or nitrates. Any quantity of organic matter it removes, with an adequate thickness of magnetic material, and slow filtration. Fortunately, a moderate layer of from 6,

* In the very lengthened water enquiry, instituted by the Government in 1851 and 1852, every chemist and engineer examined on this point, fully admitted that water could not be deprived of organic matter, held in chemical solution by any species of filtration then known.—(See the Blue Book evidence).

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to 9, or 12 inches is generally sufficient to remove all that exists in a state of putrescence, and which is, in reality the only state in which organic matter is dangerous to health. When it has become putrescent, such as in sewage matter, it is then far more easily converted into carbonic acid by the magnetic material, than when it happens to be freshly dissolved. So, that which is the most dangerous to health, is the easiest removed by this natural agent of purification.

Q. I believe there was a misbelief or prejudice against the use of your filters for removing organic matters held in solution, on the ground, I believe, that the filters themselves would become impure by the matter they removed?

A. That was so—as most who believed, and saw in fact, that it was removed, could not also be made to believe in its combustive destruction, in one and the same operation. It was the most difficult thing in the world to get people to conceive that organic matter could be destroyed by a combustive action, in cold water, and so rapidly. Many considered that I was deceiving myself. I often tried to explain it by showing that in every successive respiration, we get rid of the effête organic matter of the lungs, by a similar operation, and, with the same result—but was not always successful. An inventor is considered an enthusiast.

Q. But did this, in your opinion, operate prejudicially to the use of your invention, in the first instance?

A. No doubt it did greatly.

Q. I may take it then, that it is a demonstrable fact, that the removal of organic matters held in solution does not make your filtering medium impure, or affect or impair its action?

A. It is not affected by organic matter in solution. It is, on the contrary, asserted by some that the longer it is used the better it destroys organic matter, certainly the magnetic property does not decrease by continuous action. There are filter beds for example, large and small, some of which have been in use for 12 years, and now work as well as at first—their users say better.

Q. That is the answer that I expected you would give. I may then take it that by protracted use it is proved that for an indefinite number of years you can use the said filtering medium without its becoming impure, or its action impaired?

A. That is so, literally—just as the power of an ordinary magnet strengthens by use, at all events is not impaired.

Q. But public bodies were not convinced that this was so at first?

A. They certainly were not. The fact being so novel, it could hardly be expected. Even chemists hesitated.

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Q. Did you apply to a well-known authority on the subject—Professor Clark?

A. I did not apply to him, but the Corporation of Liverpool did, in reference to its application to their water supply.

Q. Did Professor Clark say that he could not answer for your filtering medium remaining pure—or lasting for an indefinite length of time?

A. He did. He said in his report, that whilst he viewed the invention with “feelings of the highest admiration,” at the same time, he could not guarantee that it would last 12 months—seeing that it was so perfectly new to himself—but that he could see no reason, why it should not last for any length of time.

Q. Taking that instance then of the application of the Liverpool Corporation, in your opinion, had that hesitation on the part of Dr. Clark, and other advisers, anything to do with your invention not being brought into public use at that time?

A. No doubt it had. Had it then been brought into public operation in Liverpool, I think there can be no reasonable doubt that I should not have had occasion to apply to their Lordships for the renewal of my patent to-day.

Q. May I take it then that generally, you found public bodies reluctant, owing to a want of confidence in the durability of your new filtering medium, and of its remaining continually pure?

A. That was so, and I found it vain for me to state otherwise. As its inventor, my opinions were looked on doubtingly. Perhaps, with an equal amount of knowledge as to the scientific principle, I should have done the same, but I hardly expected professional chemists would have ignored it so long.

Q. It was only length of time that could remove that prejudice?

A. No doubt—together with the results of such lengthened practice, as shown by the examples at Southport and Wakefield.

Q. You yourself, are I believe adviser to some water companies?

A. Yes, I am, but before becoming a patentee of a mode to purify water, I was so to others in the Metropolis.

Q. Have you found that your position as scientific adviser rendered you any assistance in helping the adoption of your invention?

A. No, on the contrary, I believe it has acted injuriously to my professional interests—except in cases where I happen to be well known.

Q. Was that because it was supposed that you might give their water a bad name, in order to induce the adoption of your invention?

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A. It is hardly for me to say so positively—but most companies are slow to adopt novel improvements which involve outlay—unless compelled by the public. At all events they ignore improvements as long as they can.

Lord Justice James—You had better go to the use of the patent.

Mr. Aston (to the petitioner) I believe so far from your interests being professionally advanced by your endeavours to introduce the invention, it is quite otherwise?

A. Quite otherwise.

Q. There are I believe only a few cases in which companies have been induced to adopt your invention?

A. Yes, but only where the water was notoriously bad. With regard to Southport I had been adviser to that company from its commencement, and, I believe, they placed considerable confidence in me, yet if the water had been saleable—or its impurity less visible, especially on being heated—the invention would probably not have been adopted by them.

Lord Justice James. However, it was adopted?

A. It was adopted my lord.

Mr. Aston—When was that?

A. I think early in 1862.

Q. Since that time have they continued to use it?

A. They have continued to use it ever since.

Q. We shall call the Secretary, who is here. Did you also make application and succeed in inducing the Wakefield Water-works Company to employ it?

A. I never make application in any instance. When public bodies require it they make application to me—as every public company in this country, and most abroad, are acquainted with the invention—or have had an opportunity of being so.

Q. But they adopted it at Wakefield?

A. Yes, after a long correspondence, and after numerous experiments, until at length, the directors began to believe there was something in it; but even then it would not have been adopted but for the extreme, and increasing impurity of the water they supplied.

Q. But it was adopted there. In what year was that?

A. I think in 1864. The Secretary of the Company is present, and will give what evidence you require on this point.

Q. And I believe that it has continued in use at Wakefield ever since?

A. It still continues to be used at Wakefield, and with the very best results—and, I should say, is likely so to continue.

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Q. Besides the applications by water companies, do you make a commercial use of it, in the form of domestic filters?

A. Yes. At the commencement circulars were printed and sent to the directors and engineers of water companies—and to medical men, also to architects, and others connected with water supply and building. But as people of this class had been so long taught to believe that to deprive water of its organic matter in solution was impossible, they might as well have had circulars on perpetual motion—to which many likened it. Apart from which, water companies, or their engineers, never as a rule publicly own that the water they supply is impure. Therefore they ignore improvements as long as they are able.

Q. You considered then that manufacturing domestic filters would be the best mode of bringing your invention into commercial use on a large scale?

A. I did, believing it would never be adopted upon a large scale unless those connected with water supply, as well as the public, could have an opportunity of judging for themselves, by using it in smaller filters.

Q. You looked then upon the sale of the domestic filters as a mode of proving the utility of your invention. As a means in fact of inducing its general adoption afterwards by Companies?

A. I did, to a great extent.

[The Petitioner, after further examination by Mr. Aston as to the expenditure and profits arising from the patent, was cross-examined on behalf of the Crown by Mr. Archibald.]

Q. Mr. Archibald. I will ask you one or two questions. I see by your specification you say that in your method of purification you use an oxide of iron either in lumps or granulated by crushing it to the state of ordinary sand. Do you claim as your invention the use of any oxide of iron?

A. No. I do not for example claim the per-oxide, unless it contains protoxide.

Q. That appears to be the claim in your specification?

Mr. Aston—You will find the claim set forth at page 11, line 30.

Mr. Archibald (to the petitioner) Although you have given us this interesting account of your discoveries, was it known before that magnetic oxide would purify water at all?

A. Certainly not—that I am aware of—and I speak as one acquainted with the known scientific facts in that direction.

Q. You were not aware of its ever being used for this purpose?

A. I do not believe that it had been even suggested.

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Q. That it was known to be effective for that purpose at all?

A. On the contrary, iron was always held to be a source of impurity to potable water—a thing in fact to be avoided in a town supply.

Q. You do not claim as part of your invention the manufacture of filters or tanks?

A. I do not, in this patent.

Q. But for the purpose of using it, it is necessary to use the magnetic material in filters or tanks?

A. That is so certainly, but not because the tanks themselves are made magnetic.

Q. I suppose the filters and tanks fitted with your invention would become impure by use, and require that the material should be renewed in time?

A. No, unfortunately, in a commercial sense, they do not, so that no one requires a fresh magnetic filter after the first.

Q. Not the sand or the ordinary filtering materials?

A. Where matters in suspension have to be got rid of, by mechanical filtration, a layer of sand at the top of large filters is necessary, the magnetic material being placed beneath, or better in a separate vessel if a domestic filter, because mechanical impurity ought not to touch the carbide, it being specially intended to deal with impurities in chemical solution, but whenever the top layer of sand becomes impure, by suspended matters, they are scraped off, but without interfering with the carbide beneath.

Q. But practically it is always used with sand or with some ordinary filtering materials, is it not?

A. No, not necessarily. For example, when it is applied to purify such water as that supplied in London, no sand is required, because the matters in suspension are got previously rid of by filtration, as the Companies are compelled to filter their water mechanically in accordance with the Act of 1852.

Q. Then in London you would merely use it by putting it in lumps or broken up as you describe it here, granulated, into the tanks?

A. That is virtually so, for small filters. In point of fact I prefer it to be so because there is then increased access of atmospheric oxygen.

Q. You say that this invention was taken up at Southport—to what extent has it been used there? I suppose you have visited the works while it has been in use?

A. Yes I have, frequently.

Mr. T. Spencer.]

Q. Is it used for the whole of their water purification, or only for a portion of it?

A. At present (but only latterly) for a portion of their supply.

Q. A small portion?

A. For ten years, for the whole of the supply, as they had no other water at Southport, until very recently.

Q. Then, they do not use it entirely?

A. They use it, but not entirely, for the town has increased so very much, chiefly in consequence of this water. Previously, very little could be had from the shallow wells in the town, and it was unwholesome. But the town has increased so much, and the demand for water become so great, that the Company have had to sink a another well, at a greater distance from the town, and have got an additional supply, in which there is no iron, and little organic matter—which at present, therefore, does not require filtration.

Q. Then I may take it they use your invention where it is necessary to have the water purified?

A. Just so, but that state of things has continued for ten years—and the purified water is still in use.

Q. I will not trouble you further about that—at Wakefield have they continued its use?

A. They have, ever since the first filter was laid down.

Q. And for their whole purification?

A. For their whole purification.

Q. And at Spalding?

A. At Spalding the water purified was fen drain water—and its purification continued for 8 years, with the best results.

Q. Is it used now at Spalding?

A. Not wholly so, I believe. In years of drought the available supply from the fen drain was found insufficient, so they have gone for a supplementary supply of harder water, which is brought recently from a greater distance.

Q. Then they discontinued the use of it at Spalding?

A. No, the material is in their filter beds now.

[After examination as to the charges for royalties in this and other cases, the petitioner was asked by Mr. Archibald.]

Q. Do any other public bodies than those which you have mentioned use your invention?

A. Yes, several, the Town Council, or Board of Health of Rugby for example—as well as some others, among which are Reigate, Bournemouth, and Westport, and several abroad.

Mr. T. Spencer.]

Q. When did you convince them at Rugby of its merits ?

A. I was applied to several years ago on their behalf. It was in 1865.

Q. Have they used your invention ever since then ?

A. Yes. They had a quantity of the magnetic material, but at first they would put it into their filter beds in their own way, without allowing me, to have anything to do with arranging it. So, it was thrown into the beds as so much sand or gravel ; but without reference to the conditions I usually prescribe. Subsequently, they found they were wrong ; then they applied for instructions, which I gave. Since, I have every reason to believe it is working well.

Q. Did they pay you a royalty ?

A. Oh ! no ; they would have weight for their money.

Q. They bought the stuff from you in bulk ?

A. They bought it from me in bulk, and grumbled to pay for the subsequent advice.

Q. They have not applied to you again I suppose ?

A. No. But I hear of no complaints of their water or the health of the Town now, though there used to be complaints at all times. Everyone used to hear of the bad water of Rugby, but now that seems to have entirely ceased. It is the river water purified.

Q. Do you attribute that to your invention ?

A. I think there can be no doubt, improved water has something to do with improved health.

Q. Has anything passed which leads you to suppose that public bodies will take up your invention if you get your patent prolonged ?

A. Nothing very definitely ; though I have a reasonable belief, that now it is known to have been so long and successfully in operation at Wakefield, and elsewhere, purifying water originally, perhaps, as bad as any in the Kingdom, a knowledge of the fact, is likely to induce its adoption—if not spontaneously by companies, at all events strengthened by public opinion.

Q. That is your belief ?

A. That is my belief certainly.

Q. Have you had any increased number of applications for domestic filters lately from private persons ?

A. Whenever there is any apprehension of cholera, diarrhoea, or endemic disease, I find, from the office books, that more filters are called for—and also in very hot weather, when water becomes impurer, and in those periods there is diminishment of quantity, as well as quality.

Mr. T. Spencer.]

Q. But what I wanted to know was this—whether recently you have had any increase of applications from private persons?

A. I can get at that by referring to the monthly accounts, which are here (producing a book.)

Q. To whom are your sales of carbide made in bulk, are they made to dealers in this article, or to persons who use the carbide themselves?

A. To persons who use the carbide themselves. In this book is a list of all sales (producing the same.)

Mr. Aston—You will also find in it a list, made up from the books, of all the filtering tanks sold up till now.

Lord Justice James—The question is as to magnetic carbide sold in bulk.

Mr Archibald (to the Petitioner.) Is that sold to dealers, or to persons who use it?

A. Not in any instance to dealers.

Q. Do you mean that it is sold in each instance to persons who use it themselves in a tank or filter bed?

A. That is so—to use it in a tank or filter bed—which we usually construct—or if not, furnish directions for their construction, and superintend the work.

Q. Do you know at all in what places what you have sold has been used?

A. In every case, except of course in regard to the smaller domestic filters, over which we have no control after they leave us.

Q. But as to the larger ones?

A. In every instance, we make a point of knowing where they are set up, or the carbide is to be used.

[After some further questions by Mr. Archibald, and the Lords Justices, as to the places where the system is applied, and the cost of its application, with sizes of the filtering tanks, &c., and on examining the magnetic material in a filter produced, the cross-examination of the Petitioner, by Mr. Archibald, was thus concluded.]

Q. What is generally used now by the large water companies for purification?

A. Not purification, except filtering by sand gravel. Nothing, in short, but ordinary straining—or, what is termed mechanical filtration that is, taking out what can be seen.

Q. No chemical action at all in that, is there?

A. Not any. In this respect, all the waters of the metropolis are nearly alike.

The Petitioner withdrew.

Mr. W. Harper.]

Mr. WILLIAM HARPER called in and sworn.

Examined by MR. WEBSTER.

Q. Are you Secretary to the Southport Waterworks Company?

A. I am.

Q. Have you been so since the year 1854?

A. I have.

Q. I think that Mr. Spencer was the scientific adviser to the Company from its formation?

A. He was, and continues to be.

Q. What was your original supply at Southport?

A. The original supply of the Company is from a well sunk in the red sandstone at Scarsbrick, 7 miles from Southport, the town was, at that time, comparatively small. I should suppose that at first we supplied about 250,000 gallons a day, though the supply has now got up to about 1,000,000 gallons daily.

Q. I think when you wanted to increase your supply you had to deepen your well?

A. We did not deepen the well, but pumped more out of it. We had reason to believe, that if we sunk deeper we should have still worse water?

Q. Have you found that the water became more impure as you pumped more?

A. Whilst the well was being sunk, the top water, that near the surface, was pretty pure, but when we got sufficiently low to get a larger supply, we found it was impregnated with iron, and a little organic matter, which gave an iron ochery deposit, and which rendered it perfectly unmerchantable.

Q. Not fit for domestic purposes?

A. Totally useless, except for watering the streets in dry weather.

Q. Did you try various means to make it available for the town?

A. Yes we did, but without finding a remedy. We should have been obliged either to abandon the works, or to wind up the undertaking, and so we consulted Mr. Spencer, who advised us to try Dr. Clarke's limeing process. We made the proper arrangements and after working it for about some 9 months we found it was clogging up our pipes with a lime deposit, rendering them useless in fact. Though to a certain extent it got rid of the iron, yet the pipes were rapidly being clogged up, and, consequently, would not deliver the quantity of water we required.

Q. So that it was a complete failure?

A. It was a complete failure, in our case.

Mr. W Harper.]

Q. In that state of things did you apply to Mr. Spencer again?

A. We did. We told him he must think of something else for us. We knew at the time that he had been investigating the purification of water, and that he had been making a lengthened course of experiments—which had terminated in discovering the magnetic carbide—So, when he considered it ready for practice, we adopted it.

Q. In this state of dilemma you adopted Mr. Spencer's system as soon as he brought it out?

A. No, but soon after he brought it out. After making some experiments to satisfy our directors, we adopted it.

Q. How did that answer?

A. It answered extremely well from the first.

Q. How many years have you had it in use?

A. Above ten years. After determining to use it, we had to make filter beds purposely for it, which were completed early in 1861. They are now in action with the same magnetic material we had at first.

Q. I believe considerable doubts were entertained as to its continuing to act so beneficially.

A. Well, I confess that few of us could see how it was possible that a material could continue to act so long without losing its efficacy, especially as we had previously found that every species of charcoal filters very soon did.

Q. Has it gone on to act without losing any of its efficacy.

A. It is in as good condition now as on the day it was put into the beds, and we have not had to purchase any since, except perhaps a few hundredweights to make up for some waste, occurring through carelessness in flushing.

Q. I need hardly ask you whether this has been of incalculable value to the Company.

A. No doubt it has. It saved the Company from bankruptcy.

Q. Had you paid a dividend at all previous to that time.

A. None whatever.

Q. Now I believe that you are paying a very good dividend.

A. We are paying a fair dividend—we were, up till recently paying a very large dividend, but in consequence of the great increase of the population of Southport—greatly owing to the good water we gave—we have been forced to double our capital, which has, for the present, reduced our dividend to 5 per cent.

Q. We have been told by Mr. Spencer that some times he gives a license, and sometimes he supplies the magnetic oxide?

Mr. W. Harper.]

A. That is a matter of arrangement. In our case, as his patent was virtually untried, he did not very strongly advise us to adopt it, but left it to ourselves. Ultimately we agreed to purchase the privilege of its use for our works, under his direction, for which he was contented with the very small sum of 50 guineas. As I told him, the patent was then untried on a large scale—and our directors were not quite convinced that it would be permanent—a larger sum might have stood in the way of its adoption.

Q. From your experience, if this material is used for the purpose of getting rid of organic matters in solution, or iron, is the material at all impaired?

A. It appears, beyond doubt, to be indestructible.

Q. In its efficacy?

A. Yes, in all respects. At all events, I can speak for ten years, when it is now as good as ever.

Cross-examined by MR. ARCHIBALD.

Q. How much do you put into a tank?

A. Our filters occupy a space more than twice the size of this court. From about 8, or 9 inches of thickness of the carbide is necessary to remove the ferruginous and organic impurities out of this peculiar water of ours. We pass it twice through the filters to get out the iron completely. That is, we have two pairs of filters with layers of about $4\frac{1}{2}$ inches of magnetic carbide in each. These are constructed over our covered reservoir, the whole area of which is divided into four separate filters.

Q. About what quantity of carbide would that represent?

A. I calculate by its bulk, and taking the area over which it is distributed—It is as to the thickness of the layer of carbide by which the purification is effected.

Mr. Webster.—I think you will find that a cubic foot and a hundred pounds will be somewhere about an equivalent—as stated by Mr. Spencer.

A. That is somewhere near it.

Mr. Archibald.—You have sand and gravel over it?

A. We have a little sand to intercept leaves, but no gravel.

Q. What's the depth of sand?

A. About 4 to 5 inches.

Q. That you remove?

A. The top we scrape off when needful, and then wash it with a stream of water and put back again—ours are a little different from the filters in ordinary use, as the water is a peculiar one.

Q. Do you attribute its effects entirely to chemical action, or are you sure that it is not merely mechanical?

Mr. W. Harper.]

A. The chemists who are present can answer that best—all I can say is, that it does its work admirably—which everything else mechanical that we tried did not—there is, beyond doubt, a physical or chemical action which it exercises on impure water, but which is very different indeed from the riddling, or mechanical straining filtration in ordinary use, in which the organic matter is left in the water altogether untouched.

Q. And the company intend to continue the use of it?

A. I must explain—that the company constructed their original well in the year 1854. But from 1861, up to July 1870, no water was sent to Southport by the company which was not filtered through Mr. Spencer's magnetic filter, but in consequence of the numerous complaints as to the insufficiency of our supply from that well, the town having increased in population during this time more than double its original extent, we were obliged to obtain an Act of Parliament to authorize us to make a larger well at some distance inland. The water of this well, as it happens, does not require filtration, because it does not contain the impurities contained in the first—and therefore, the original Scarsbrick well water still passes through Mr. Spencer's filter, but in regard to the Oughton water that (from our new well) we have no occasion to use any filter for it.

Q. As I understand, you never have had any occasion to buy any more magnetic carbide?

A. Yes, perhaps some few cwts. amounting perhaps in all to less than a ton, which we have added since.

Q. I thought it was indestructible and did not require renewal?

A. It certainly does not require renewal; but in course of time in our case, there was some slight loss of quantity by careless flushing out the iron ochre after it has been taken from the water—but no flushing is required when dealing with organic matter alone, and and therefore, no loss.

Q. But only to a very small extent?

A. Only to this very small extent, but only, in our case, where iron has to be dealt with as well, though not necessarily.

Q. What you have now will answer your purposes with very small additions for some time to come?

A. With very small additions—but ours is a peculiar case, as, in consequence of the iron, we have to flush the filters upwards.

Q. You do not require it for your new well?

A. No, only for our first well in which the iron still continues as at first.

The witness withdrew.

Mr. Aston. We propose now to call Mr. Sykes.

Mr. J. Sykes.]

Lord Justice James. Is this the gentleman who keeps the accounts?

Mr. Aston. No, my Lord, we are going to call a gentleman from the Wakefield Water Works, in regard to a very different quality of water.

Lord Justice Mellish. Is it the sewage water at Wakefield?

Mr. Aston. It is in great part sewage water, as I am informed.

Lord Justice Mellish. I should like just to hear about that.

MR. JOSEPH SYKES called in and sworn.

Examined by Mr. Aston :

Q. I believe that you are Manager of the Wakefield Water Works?

A. I am.

Q. And you have been so for 12 years?

A. Yes, I have.

Q. I believe that you have had great difficulty with your water?

A. Yes, very great difficulty indeed, since the sewage was wholly turned into the river.

Q. Have you applied to several engineers and chemists, in order to enable you to overcome those difficulties?

A. Yes, to a considerable number of the most eminent in both professions.

Q. Eventually you had recourse to Mr. Spencer?

A. Yes, we had.

Q. Did he do for you what other engineers had been unable to do?

A. He certainly did—both as to the purification, and mechanical filtration of our water.*

Q. Will you tell their Lordships, as shortly as possible, what Mr. Spencer has done for you?

A. I applied on behalf of our company to Mr. Spencer, some years previously to 1864 to know about his patent, which I had heard of, and he very kindly gave me all the information he could, and instructed me how to make experiments which I did, and they turned out so successful, that our directors were induced, after a good deal of deliberation, to lay down filters on his plan, which we did in 1864. At that time the water which we now take from the Calder (perhaps their lordships will have already heard something about

* At the same time, Mr. Spencer was greatly indebted to Mr. Sykes for the very efficient manner in which he carried out the plans

Mr. J. Sykes.]

the Calder in the government reports) was getting very bad. Complaints were more and more loudly made, and we were induced to adopt this system as a matter of salvation—we should have been annihilated unless Mr. Spencer's system had cropped up.

The Judge of the Admiralty Court.—Poisoned?

A. I do not say exactly poisoned, my lord, but I mean annihilated as a company. We laid down two filters under Mr. Spencer's direction in 1864, and the effect on the water was really marvellous. From that time to this, we have used Mr. Spencer's magnetic material for the filtration of the whole of our water, and now we have no complaints. Previously, we had a sand and gravel filter, on the ordinary construction, but which was of very little or no service.

Mr. Aston. What is the quality of the water which you filter?

A. We take our water from the Calder, which, without this process, could not now be supplied for any purpose.

Q. I believe that that river is greatly polluted with sewage matter?

A. I believe that it contains the sewage of over 150,000 inhabitants—all of which finds its way into the Calder, a little above the point from where we are obliged to take our water.*

Lord Justice James. It runs through a populous district before it comes to Wakefield?

A. It runs from Todmorden above Wakefield, my Lord.

Mr. Aston. Is it very much contaminated with sewage water?

A. Very much so. It is a narrow navigable river. It also receives the refuse water of several chemical and other manufactories, which greatly discolours the water.

Q. Notwithstanding that, you find that Mr. Spencer's filtering medium removes all the impurities.

A. We have the best reason to know it removes them effectually.

Q. Had you yourself, and had your directors any doubts as to the lasting qualities of Mr. Spencer's filtering magnetic media?

A. Certainly, at the commencement, we had grave doubts.

Q. From your experience in connection with water works, do you think that those doubts had the effect of preventing the material from being extensively employed at first?

* The Company's works were made prior to the application of the Health of Towns' Act to Wakefield. In subsequently sewerage the town according to this Act, the engineers decided that the position of the outfall of the sewage, should be at a point a very short distance ABOVE the one where the Company took its water, and where, from the peculiar circumstances of the case, they are still obliged to continue to take it.

Mr. J. Sykes.]

A. Of this I can have no doubt; because a material which actively performs its work, at all times—night and day, and yet, loses none of its power, seems to most people an impossibility. It did so at first to me—but now I can vouch for such being the fact, and also that it continues to act as well now as it did at first.

Q. I may ask you whether anything short of positive proof of this nature would have removed those prejudices?

A. I do not think anything else would, at the commencement; but now the lengthened proof, shown by the results we have had at our works, surely ought to convince the most sceptical.

Lord Justice James.—The water is really considered good in Wakefield now?

A. The water is now considered very good, my Lord. I have a sample here which I took from my own tap before I left Wakefield yesterday.

[The witness produced a bottle, which was handed to Lord Justice James, who, on pouring some of the water into a tumbler, and drinking about half of it, said it was—"very good water indeed." It was then examined by Lord Justice Mellish, and the other Lords of the Court.]

Mr. Aston.—Is that the Calder water?

A. That is the Calder water, as purified by Mr. Spencer's system.

Q. I believe that the local medical men in the first instance were opposed to the system were they not?

A. Yes, several of them very much so—as well as others, who were taught to believe that water could not be purified, by any means whatever.

Q. And that I suppose prevented its use to a considerable extent?

A. It might to a certain extent; but such is certainly not the case now. Even our death, or disease rate, is less than formerly.

Cross-examined by Mr ARCHIBALD.

Q. Have you any analysis of your water?

A. Yes, several. In order to satisfy ourselves as to the Calder water, after Mr. Spencer's purification, we had one analysis by Professor Way, another by Mr. Dugald Campbell, and one by Dr. Alfred Swaine Taylor (handing in the documents), but these gentlemen were not told in this instance, from whence the water came. The samples were taken and sealed at the filter beds by a medical gentleman who was opposed to the system of purification.

Q. I may take it that the results contrast favourably with other water?

Mr. J. Sykes.]

A. Very much so. All the analyses we had then, and since, state that the filtered water is very pure, and well adapted for a town supply, and that it contains a relatively small quantity of organic matter, and that the little left in it, is not in any degree putrescent.

Q. Have you ever tried this yourself on purely sewage water?

A. Not upon pure sewage. I have had no occasion to deal with sewage, other than that which is combined with our river water, which is sometimes very turbid, and discoloured from woollen dye, and other works on its banks.*

The witness withdrew.

Mr. Webster. The clerk is here who has kept the accounts, my Lord.

Lord Justice James. Let us have him to verify the accounts.

MR. CHARLES BEAUREGARD sworn.

Examined by—Mr. WEBSTER.

Q. Are you clerk to Mr. Spencer?

A. I am.

Q. How many years have you been so?

A. Over 8 years.

Q. Some accounts have been produced—did you make them out from the books kept in the office.

A. I did.

* It will afford some idea of the state of the Calder water, previous to its purification by the Magnetic Process, to quote the following from the "Times" of June 5th of the present year. It occurs in a notice of the last Report of the pollution Rivers Commission:—

"The Commissioners steamed up the Aire and the Calder, and took samples of the black and turbid water, with the oily film upon its surface, and emitting the odour of sewage and gas tar. Here, however, a Wakefield manufacturer had been before them, and he produced to them the river's own testimony, in the form of a memorandum written in what would pass as pale ink, 'Dedicated, without permission, to the Local Board of Health, Wakefield, this memorandum written with water taken from the point of junction between the river Calder and the town's sewer. The Commissioners give a fac-simile of this memorandum.'"

Though this account of the Calder is much exaggerated by the sensational tendencies of one of the Commissioners, still the water of this river, in its ordinary state, is sufficiently bad to render its purification for the supply of Wakefield, a very great triumph of modern science—and which might be applied to the water of every river in the kingdom without difficulty.

Q. Are the accounts accurate ?

A. They are. They were subsequently verified by Mr. Bower.

Q. I believe that you have the books here, and the cheques if we should want them ?

A. Yes, all are here.

The witness then withdrew.

Mr. Aston. Mr. Dugald Campbell is here if your Lordships would like to hear him as to the purity of the Wakefield water.

Lord Justice James. I think you need not call him.

Mr. Archibald having addressed their Lordships on behalf of the Crown, the case closed, when :—

Lord Justice James announced, that their Lordships would have great pleasure in recommending to her Majesty—that the patent should be extended, for the full term of SEVEN YEARS.

SUPPLEMENTARY EVIDENCE.

THE HEALTH OF WAKEFIELD SINCE THE PURIFICATION OF ITS WATER SUPPLY.

A Report of the Commissioners of Lunacy states that since some wells in the extensive grounds of the large County Lunatic Asylum near Wakefield, have been closed, by their order :—“The mortality has been below the ordinary average of “the Asylum ; and in connection with it we have to remark, that a “portion of the water in use last year, when diarrhoea prevailed to “so considerable an extent, has been disused, and the rest (namely, “the supply from the Town works) has been purified and improved “by the Company. There is now nothing epidemic in any of the “sick cases. *One man only* is in the Hospital suffering from “dysentery.” (*Report of Commissioners in Lunacy, 1868.*) The same Report further shows, that with an increased number of inmates, the whole mortality of the asylum is greatly less, than it ever was known before.

The following is from a newspaper report of a conference between the River Commissioners, and the Town Council, and is cited here

as further showing the high sanitary state of the town since the water was purified by the Magnetic process:—

Mr. Alderman Rhodes.—The magnetic carbide process works very well? (*Mr. Spencer's process as applied in Wakefield.*)

Dr. Frankland.—Very well indeed.

Mr. Morton.—But you are still liable to the risks my colleague has referred to.

Dr. Wade, the medical officer of health for the borough said, that during the last two years a great reduction of epidemic disease had taken place. There was very little now.

Dr. Frankland.—Did scarlet fever prevail to any extent during the summer?

Dr. Wade.—Yes, to a considerable extent, but without any fatal consequences.

Dr. Frankland.—From the Report we find that at the time of our predecessors' visit to Wakefield in 1866, there was one or two cases of cholera? Did it spread?

Dr. Wade. It did not.

The "one or two cases of cholera" thus spoken of by Dr. Frankland in 1866, was in reality *only one*—and that not fatal, notwithstanding the town had been subjected to a great flood in the course of the same year. It was proved before the former Commission referred to, that this single patient came from a neighbouring town. The fact of this case is exceedingly valuable, as it shows cholera to have been in Wakefield at the time, but *without the power of spreading*—and this too, when, during the same year (1866), according to Dr. Budd's statistics read at the Social Science Meeting at Bristol 10,000 persons died in the metropolis of this disease.

In the course of this Conference at Wakefield, Dr. Frankland is reported to have said, that he was bound to admit, that: "*the filtration of the town's water produced in it a degree of purity that was really marvellous.*"

To the above instances may be added that of George Town, Demerara, where magnetic filters, from the plans of Mr. Spencer, have been in use to purify the water for nearly 9 years—and, with the very best results. This water could not previously be used for any culinary purpose. Even its exhalations were pestilential in the warm season.

Buenos Ayres is also following the example of George Town, and is at present laying down a series of magnetic filter beds, the material for which has been recently forwarded by Mr. Spencer.

MR. SPENCER'S MODE OF CONSTRUCTING FILTERING RESERVOIRS FOR WATER WORKS.

Previously no system of filtration aimed at more than depriving water of the suspended impurity visible to the eye. In Water Works, this is effected by slow filtration or straining through graduated layers of sand and gravel, as practised in the Metropolis. Though the actual filtering is intended to be performed at the surface of the upper layer of fine sand, yet lower layers of considerable thickness of coarser material are found indispensable, to retard the passage of the water, without which, the impure particles would be carried below the surface, and not only render the filtering operation valueless, but contaminate the whole mass of retarding media in the filtering bed—besides fouling the water, which too often takes place.

Although the thickness of the upper layer of fine sand does not exceed 3 feet, the coarser retarding layers on which it rests are not usually less than 4 or 5 feet. Consequently, an ordinary filtering bed is made of sufficient depth to contain about 7 feet of filtering media, in addition to a "head" of 5 or 6 feet of unfiltered water. To allow therefore, for the contingences incidental to the prevailing system, "Filtering beds" or more properly "Filtering Reservoirs," are engineering excavations of from 13 to 15 feet in depth, faced with hydraulic masonry, or brickwork, laid in cement, and lined at the back and bottom, with layers of carefully tempered clay, where the subsoil is permeable. In short, as much care is taken to maintain "water-tightness" in a filter bed as in a dock for shipping.

By the new system, thoroughly effective mechanical filtration is secured with half the usual thickness of filtering media—whilst the whole depth of the filtering reservoir, including the space above for water, need never exceed 7 feet—or half the usual depth. These advantages are obtained by means of stoneware regulators placed at the bottom of the bed, which have the effect of retarding the downward passage of the water—at the surface. So that, when the water reaches the bottom, these regulators cause it to *turn upwards* before it can pass from the filter. Consequently the *downward* action of the top water is so balanced from below, that the finer particles of suspended matter are thoroughly intercepted *at the surface*; whilst increased aeration of the water and filtering media, is given from the air drains below.

The regulating apparatus also causes the water to descend through the sand, not in straight, but in a series of conoidal lines, intersecting each other, and converging below at a number of centres, at each of which the water is bent upwards, as in a spring, before it can reach the lateral drains; whilst only a certain quantity of water can pass in a given time. The surface of the bed is thus kept free from hollows, whilst the perfect interception of the lighter particles of suspended matter is secured at the top. Moreover, by Mr. SPENCER'S mode of supplying the unfiltered water at the centre, instead of, as formerly, from an inlet at the side, the filtering process goes on alike steadily throughout the whole area; nor, on letting in the water after temporary stoppage, is the surface so liable to be furrowed up as by the old mode. The Principle of this system combines upward and downward filtration in one and the same operation—a result never previously obtained, though long a desideratum.

Besides these practical advantages, its cost of construction is about *one-half* that of the usual mode, as only half the depth of reservoir wall and excavation is required with less than half the quantity of filtering media—and where the water has to be pumped to a given level into the filtering beds, a large saving of steam power is also effected.

It is important to add that the new system is not confined to Magnetic, but answers equally for mechanical filtration through sand and gravel.

N.B.—The Filtering Works now constructed at Calcutta are in accordance the mode here described.

