which this material finds useful application. Canvas and cordage treated by the Willesden process are not increased in weight or rigidity, as is the case when tarred and otherwise treated; whilst a high degree of freedom from mildew, mould, rot, and decay, and greater durability generally are thus secured.

A fuller description of the various uses to which these Willesden fabrics may be put will be shortly given in a paper on the subject to be communicated to the Society of Arts.

DISCUSSION.

The CHAIRMAN said he was sure the Society would thank Dr. Wright for bringing before them a very useful application of a very well-known reaction. It was very evident that such a method of waterproofing fabrics and rendering them indestructible must have many practical applications. It was interesting to know from recent experiments made in France with regard to the most effectual method of destroying poisonous germs, that in many cases sulphate of copper exceeded all other disinfectants. Of course in moist climates, where mildew and rot were specially to be feared, these substances treated in the manner described would be practically indestructible. Sleepers had been already pickled with sulphate of copper to a certain extent, but the addition of the ammonium salt with its solvent action on the cellulose, pointed to the possibility of a much wider application of this process.

Mr. TYRER asked whether the thick ropes, samples of which were shown, were waterproofed throughout, or was the exterior only waterproofed.

Dr. WRIGHT replied that the process as applied to ropes and canvas was not so much intended to render them waterproof in the sense of keeping the rain out, as to prevent mildew and rot, to which ordinary canvas was subject. He might call attention to the various specimens exhibited, showing the different effects on strips of canvas, paper, and card, of immersion in water or moist air when treated with this liquid and when left untreated. If the materials were boiled the effect would be still more marked; treated canvas might be boiled for any length of time without any apparent effect of any kind being produced, whilst ordinary canvas would be more or less injured, and of course paper or cardboard would speedily go to pulp. There was another specimen in which several strips of paper had been dipped in the solution for a portion of their length and then passed through rollers, when they became inseparably agglutinated together, and would sustain a much greater weight than before.

Mr. JOHNSON asked if the process added anything to the strength of the card.

Dr. WRIGHT said the amount of strain the material would bear after treatment was very greatly increased, as could be proved by attaching a weight to it.

Mr. NEWLANDS suggested that the same effect would be produced by merely gumming the sheets together. He should like to know if this process was applicable to filtering cloth, and if it would strengthen it. If so, even at a considerable cost, there would be a considerable use for it. Serim cloth was mentioned, and that was used largely in the sugar manufacture, but it rapidly wore out.

Dr. WRIGHT remarked that there was a great difference between a material formed of several sheets of paper by this process and a piece of pasteboard made in the ordinary manner. The latter (the pasteboard) would be reduced to its pristine elements by exposure to water; but Willesden card would not be affected, the agglutination being permanent. With reference to the possible superiority of the prepared canvas as a filtering material, he was not aware that it had ever been tried; but he should imagine it would be somewhat less porous than before, on account of the filters being coated with a kind of glutinous cement, which would render the crevices between the warp and woof smaller. But if a somewhat more loosely-woven canvas were treated, it would then no doubt be as permeable to fluids as a more closely-woven kind untreated; and no doubt it would resist the action of boiling saccharine fluids, which he supposed Mr. Newlands referred to.

Mr. EAST asked if it would be possible to treat the material for canvas and ropes before manufacture. That would get over the difficulty just referred to.

Dr. WRIGHT said there was no doubt the hemp fibres might be dipped, but he did not think they would spin so well. If that could be got over by altering the machinery there would be no other obstacle. He should fancy the fibres would be more like bristle after dipping.

ON THE FILTRATION OF POTABLE WATER.

BY S. H. JOHNSON.

THERE are few subjects of greater importance to the community in general than the quality of water used for drinking purposes. With the increase of civilisation and the consequent aggregation of the populations into cities and towns, the difficulties have ever increased, in consequence of the pollution of all the readily accessible water by the excreta and refuse of the people. In examining into the subject of water supply it is most striking that, from age to age up to the present, great ignorance as to the transmission of disease by polluted water should be almost universally prevalent, and we do not find until within the present century that our knowledge of the subject has received any important acquisitions. The reason of this is clearly due to the absence of chemical knowledge and ignorance of the inductive methods of research, and although our knowledge of the subject has been greatly expanded during the past fifty years, yet it must be admitted that at present we are only on the threshold of that knowledge which the importance of the subject merits and demands. Intimately connected with the subject of water as a beverage is the zymotic theory of disease, and although the specific organisms producing cholera, diarrhœa, or typhoid symptoms have not been identified, yet the evidences by analogies of results produced, and the similarity of effects of various reagents and conditions on infected liquids are so marked, when compared with like treatment of known organisms, that the conclusion that they are vital organisms, not capable of transmutation, is almost irresistible. However, whether this be so or not, there can be no doubt whatever that the specific poisons producing such diseases are in the vast majority of cases traceable to, and derived from, organic matter in a state of decomposition, and in nearly every instance such organic disease-producing matter has proved to be derived from infected human excreta in sewage, contaminating the drinking water of the persons attacked by the disease named. It is not the object of this paper to do anything further than state these views, about which so much already has been written. It may be taken as granted that the general consensus of scientific opinion is in favour of the idea of the propagation of these diseases by living organisms, and that these organisms are derived from drinking contaminated water. It is well we should have a few striking examples of the evils resulting from drinking contaminated water fresh in our memory before proceeding with the subject of filtration.

CASE I.*—In the year 1866 an epidemic of cholera visited London, from which the mortality was, in the eastern district, 3,700, and in the rest of London 660. It has been demonstrated to have arisen in this way: A sailor was landed at Southampton suffering from Asiatic cholera, who went on to London, and it is established that the bowel discharges of this patient passed into the Lea at a point 200 feet distant from one of the service reservoirs of the East London Water Company at Old Ford. There is also conclusive evidence that on several occasions, about this time, this infected water was admitted into the service reservoir without filtration, the supply of filtered water having run short, and this water was distributed by the East London Water Company, and it was found that "the area of intense cholera in 1866 was almost exactly the area of this particular water supply, nearly, if not absolutely, filling it, and scarcely, if at all, reaching beyond it."

CASE II.—A district of London on the south side of the river was visited with special severity by Asiatic cholera as often as it had been epidemic in London. On examination it was found that this district was co-extensive and conterminous with the district supplied by two of the London water companies who drew their supplies from the grossly-polluted water of the Thames at Battersea—the Lambeth and the Southwark and Vauxhall Companies. These were competing companies, and a duplicate system of mains side by side supplied the houses with water indiscriminately, and in the same streets, in fairly even proportions. In the visitation of cholera of 1848-9 the tenants of each of the companies suffered in about equal proportions. In the next outbreak of cholera, 1853-4, the source of supply for the water had been changed from Battersea to Thames Ditton by the Lambeth Company, and the Southwark and Vauxhall Company continued to draw their supply from the grossly-polluted water of the Thames at Battersea. Here, then, we had an intermingled population, part of whom were supplied with a somewhat diluted and strained sewage, compared with which the remainder might be said to have been supplied with fairly pure water. That portion of the population supplied with foul water had a death-rate from cholera of 130 to every 10,000, and the remainder, who drank the moderately polluted water, had a death-rate from the same cause of 37 to every 10,000, so that the population drinking foul water "suffered 3½ times as much mortality as the population drinking other water," and there was an analogous correspondence of the deaths from diarrhœa. The number of lives involved in these experiments was 511,000, so that the results obtained are most reliable and conclusive, the two portions of the population being alike in all other conditions with the exception of water supply.

CASE III.—The violent outbreak of cholera which took place in the year 1854 in a small district in Golden Square, St. James's, Westminster, by which, within a radius of three minutes' walk of a polluted well, 609 persons lost their lives in the course of a few days. "It was shown by Dr. Snow (1) That the outbreak, properly so called, was principally confined to the area about the Broad Street pump. (2) That 61 out of 73 persons who died during the first two days had been accustomed to drink the pump water either constantly or occasionally. (3) That the water was used in various other ways, and might so have been taken in cases where its use in the ordinary way could not be distinctly traced. (4) That in the workhouse, where the well water was not used, only 5 deaths occurred, whereas 50 would have been a ratio proportionate to that of the neighbourhood around. (5) That in a factory employing 200 people, where the water was drunk daily, 18 people died. (6) That 70 men employed in the brewery in Broad Street never drank the water, and escaped cholera. (7) That in a number of individual instances, which was particularly investigated, the drinking of the water was followed by cholera. In one case a lady living quite away from the district, who had the water sent out to her, died after drinking it. Her niece also died under the same circumstances (8) That at any point decidedly nearer to another pump the mortality from cholera as a rule ceased, and that in an inquiry extending over 48 fatal attacks which took place nearer to another pump, many apparent exceptions were found to be cases of death in persons who really had a preference for the more distant Broad Street water. (9) That in a particular street, containing 14 houses, the only four which escaped without a death were those in which the Broad Street water was never drunk. (10) That this water was used for drinking purposes only, and was used cold. From all these several facts Dr. Snow is of opinion that the outbreak was attributable to the well water as the medium of dissemination of the cholera poison. He believes, moreover, that the well water must have been not merely generally contaminated by cesspool drainage, but especially with the evacuation of a cholera patient. These conclusions of Dr. Snow have been confirmed in a remarkable manner by Mr. Whitehead, who at first entertained adverse views and investigated the matter independently.

CASE IV.—The great unhealthiness of Millbank Prison was for a number of years a source of great anxiety, and many measures were resorted to for its improvement, but in vain. Typhoid fever was especially fatal. At length, in the year 1854, the supply of the prison with water pumped from the Thames was discontinued, and the water raised from the artesian well in Trafalgar Square was substituted for it. Immediately on the introduction of the new supply the health of the prisoners improved, and from that date up to 1872, a period of 18 years, there have been only three deaths from typhoid fever, not one of which was contracted in the prison. Although at previous times the prison was so unhealthy that at one time as many as 500 convicts out of 880 were sick in 1849, and the death rate had reached 82 per 1,000, the average since the Thames water has been replaced does not much exceed 12 per 1,000.

CASE V.—At Caterham and Redhill a well-authenticated instance of the pollution of the water supply in a group of towns and villages of the specific poison or organism of typhoid or enteric fever was brought before the Society of Arts in the year 1879, by Dr. Thorne, at the Conference on National Water Supply, Sewage, and Health. It appears that an outbreak of enteric fever occurred simultaneously in this cluster of towns and villages, and 196 persons were attacked within 14 days, 21 of whom died. Since some of the affected districts were quite isolated from the rest, the simultaneous character of the attack in each of the places was very remarkable. This led to an investigation of all the usual conditions likely to affect the case. The sewage and drainage, the means of disposal of excreta and refuse, the milk supply, etc., were each inquired into, but nothing could be found throwing any light on the subject; but, on the contrary, in these matters, there was no condition in common in all the places affected. The single prevailing condition in common in all the places was the water supply; but this was thought to be almost above suspicion, being derived from wells more than 500ft. deep in the chalk. However, in the

* The cases Nos. I. to IV. are abbreviated from the Sixth Report of the Royal Commissioners (1868) on Preventing the Pollution of Rivers.

infected district there were 1,400 houses which were not supplied by the water from the company's mains, and it was found that not one person was attacked who were occupants of these houses, who had not drunk of the water from the company's mains. This was almost conclusive that it was in the water supply the mystery would be solved. An investigation was made, and it was found that the water company had been constructing an adit between two of their wells at this time, in which a workman was employed who, it was afterwards discovered, was suffering from an attack of enteric fever, and it was also proved, and admitted by this man, that, notwithstanding the regulations to the contrary, he was compelled to evacuate the diarrhœal discharges in the adit. The symptoms in the case were well established as those of enteric fever. This quite explained the mystery. There are literally thousands of cases which could be adduced to show that a fruitful source of prevalent zymotic diseases is the drinking of water polluted with organic matter of sewage—indeed, it has been computed that the deaths from this cause alone amount to at least 120,000 annually in the United Kingdom! So that it may be said with truth that England has lost far more by drinking dirty water than by the deaths of all the soldiers and sailors that have fallen in all the battles she has ever fought, and yet England in sanitary matters, and especially in the matter of sewage disposal, is far in advance of every other nation. From the cases heretofore cited, it is evident that when potable water acts as a carrier of infectious diseases, the infection is either derived from, or always associated with, organic matters of animal origin. It does not, however, follow that all animal organic matter contained in water must necessarily be morbific in its effects—rather the contrary is proved by all our experience hitherto. The very fact of the occurrence of epidemics of particular types of disease shows clearly that the existence of infection in a water is not the invariable result of animal contamination, but rather the exceptional condition. In the absence of any known method of determining the presence of infection in water, it is considered that the only safe course is the rejection of such as have an appreciable amount of organic pollution of animal origin. The zymotic theory certainly appears to explain the facts connected with the occurrence and transmission of the class of diseases we have been considering in a way that no chemical theory, when compared with it, can for a moment appear tenable. The assumption that living organisms of intransmutable type and of exceedingly minute dimensions are the cause is being daily more and more strengthened by the researches of biologists like M. Pasteur and others, and the identification of the specific disease-producing ferments and their habits, such, for instance, as that producing splenic fever in sheep, add confirmation to this view. On this assumption the necessity for the presence of certain kinds of organic matter is apparent, as they doubtless form a suitable pabulum for their growth and development, existing like bacteria and other ferments, by breaking down colloid organic matter of complex molecular structure into simpler forms or else into inorganic bodies.

Having now generally stated the grounds for objection to the use of water polluted with sewage for drinking purposes, apart from any sentimental objections, there can be no doubt that the subject is of vital interest to every individual to whom only a supply of more or less polluted water is accessible. With the water supply of our cities and large towns in many cases no exception can be taken. The cities of Liverpool, Manchester, Glasgow, Dublin, and Edinburgh are supplied with upland waters above the region of any sewage contamination, but London, Birmingham, Bristol, and a large proportion of the smaller towns of the United Kingdom are still supplied with sewage-contaminated water from rivers and surface wells. In London, excluding the district supplied by the Kent Water Company, the average quantity of sewage contamination in the water supplied for drinking purposes is 3 per cent., or about one quarter of a pint of sewage per gallon, an amount that is not pleasant to realise. There is no doubt that the proper remedy is to change the sources of supply from the polluted waters of the Thames and the Lea either to wells in the chalk, the lakes of Cumberland, or the head waters of the Severn basin; but so long as the health and mortality of the people are permitted to be subservient to the interests of capital, it is probable that even in London we shall be obliged to drink water polluted with human excreta. Although in many things the institutions and material welfare of this vast metropolis compare favourably with the best of all that can be found in past history, yet in this matter of water supply we can learn a lesson from ancient Rome—the enormous works which she constructed, the remains of which to this day form a monument to her energy and her just appreciation of the best interests of her people. If the old Romans were here, with all our modern appliances and advantages, this matter of a pure water supply would not have been allowed to linger on account of vested interests, but they would have smiled and done the work. In the paper read by my friend Mr. Hutchinson, on the last occasion of our meeting, he brought before your notice the method by which not only the whole of the solids held in suspension in the sewage of towns can be cheaply and completely got rid of without nuisance, but also a large proportion of the most objectionable colloid organic bodies, by means of precipitation with alumina and lime; and there can be no doubt but that the quality of the London water supply would be greatly improved if the excreta and refuse of all the populations, amounting to 800,000, in the upper Thames basin above the intakes of the metropolitan water companies, were clarified in this way. There would still, however, remain considerable pollution by the surface drainage from highly-manured agricultural lands. So long as we derive our drinking water from sewage-polluted rivers, the method of filtration employed at our waterworks, in the interests of public health, should be the most perfect that our present resources and knowledge can supply. How far the present means employed are adequate we shall now consider. The means employed by water companies for the purification of foul and turbid river water are of the very simplest character, and have undergone no improvement whatever since sand filtration was first recommended by Mr. Telford and Dr Brand in the year 1828. The water is first collected into reservoirs, where the heavier impurities are allowed to subside, and then, after some days or weeks, the partially clarified water is passed through a graduated filter bed (about 6 to 8 feet deep) composed generally of successive layers of boulders, large stones, small stones, coarse gravel, fine gravel, and lastly one or two grades of sand. Through such a filter bed the water is permitted to pass at the rate of from 3 to 9 inches in depth per hour—that is to say, from 1½ to 4½ gallons per square foot per hour. For Thames water the latter speed is considered much too fast, because it is found that if the rate much exceeds 6in. per hour some visible suspended solids pass through the filter. Thus an acre of the filter beds so prepared is capable of filtering from 60,000 to 100,000 gallons of water per hour. It has frequently been asserted

that a considerable proportion of organic matter in solution is oxidised and converted into nitrates and nitrites, but that this is not the case is evident by comparison of the water of the London companies after subsidence and before filtration and after filtration through the filter beds.*

Names of Companies.	Nitrogen as Nitrates and Nitrites. Parts per 100,000.	
	After Subsidence but before Filtration.	After Filtration.
West Middlesex	·329	·335
Grand Junction	·356	·315
Southwark and Vauxhall	·318	·315
Lambeth	·318	·361
Chelsea	·312	·307
New River	·310	·310
East London	·311	·311
Average of 7	·330	·327

From this table it appears that the average result of filtration of the seven companies' water who use filter beds in London shows that the oxidising effect is practically *nil*, the water having, if anything, less nitrates and nitrites after filtration. From these figures it is evident that there is nothing in the nature of surface oxidation takes place by reason of the water being brought in contact with air in the pores of the filter. It is manifest that the removal of organic matter is simply mechanical, and that the organic matter removed was simply in suspension. It requires but little consideration that one may be convinced that a sand filter is at best a rude contrivance to employ for so delicate an operation as that of filtering the excessively fine matter in suspension at times in river water; and were the case dependent on and governed by the size of the pores or interspaces between the particles of sand alone, such a filter would be altogether inadmissible. But when it is considered that the difference in the dimensions of the particles of sand and the invisible particles which give to water an opalescence is very great, and that in fact the interspaces in the sand filter are reservoirs in which the fine particles of solid matter can subside, then it is more simple to comprehend its operation. It has been found that water with a turbidity from very fine suspended matter cannot in any reasonable time be clarified sufficiently by simple subsidence in a waterworks reservoir, and notwithstanding this it can be clarified quickly by a sand filter. On the assumption that the upper surface of each grain of sand becomes a catchment shelf for the suspended matter deposited on it, the *modus operandi* is clear. We may to this end consider a filter bed as a modified subsidence reservoir having two altered conditions—namely, a greatly-extended area, and a greatly-diminished depth. Now, if any of you will take the trouble to observe, if you have not already observed the fact, you will find that the time required for matter in suspension in a fluid to completely subside is in the direct ratio of the depth of the vessel—that is, the deeper the vessel the longer time it will require. For the sake of expressing the case numerically we will assume that we have a filter bed of three acres area, the sand in which is 50in. deep, and that the interspaces between the grains of sand average ·01in. in depth; that there is an average of 20 such spaces to the inch depth of the sand of the filter bed; that the area of the available catchment shelves on the upper surfaces of the grains of sand in each of these twentieths of an inch is one-third of the area of the upper surface of the filter bed. Then we have—

$$\frac{20 \times 50 \times 3}{3} = 1000$$

acres, equal net area of catchment shelves, so that the filter bed is equivalent to a subsidence tank of 1,000 acres in extent, $\frac{1}{100}$th of an inch deep. If we now compare this with a subsidence tank 100in. deep, and bearing in mind the fact that the time required for subsidence of suspended particles is proportional to the depth, the matter would be deposited completely in the filter bed in $\frac{1}{10000}$th of the time required for deposition in the subsidence tank 100in. deep. It is simple thus to understand the action of a sand filter in removing a slight turbidity in water. And it will now be readily understood how that a very slight increase in the rate of flow of the water through a sand filter will be sufficient to carry the deposited matter through the filter. Thus the work done on a given area of filter bed is of necessity limited, and hence the necessity for large areas of sand filters. If we consider the great importance of this subject of the filtration of water at our waterworks, and that it is in the solid matters in suspension that all the danger exists (for we cannot conceive it possible that the disease-producing organisms can exist absolutely in the liquid state), it would seem more desirable, if a positive filter of so fine a porous texture were used, that it would hold back mechanically all insoluble organic matter, however fine. The Porter-Clark process for softening water, which Mr. Porter so amply brought before the notice of the Society at the last meeting, much more closely approximates to this condition than a sand filter, by making use of the fine precipitate of carbonate of lime, after the softening is effected by Clark's process, as a filtering medium for the water. This is evident by the disappearance of the yellow tint due to organic matter, and present in all the London waters, and by the beautiful blue of pure water which then becomes apparent. If this process of Mr. Porter's and Dr. Clark's were substituted for the present crude and imperfect subsidence tank and filter bed, there can be but little doubt that not only would the water supply of London, or any other large town where it is required, be greatly benefitted, but it is very probable that a positive economy would result to the water companies. Although a supply of better and purer water is much to be desired, yet that alone is not sufficient protection, and so long as the present system of house cistern and intermittent supply exists additional safeguards should be employed; and in country places and villages, and towns where the water is supplied from surface wells, a good method of purifying drinking water for household use is much to be desired. If all the cases of sickness, and the maladies of various kinds which are directly traceable to the contamination of water in household cisterns, could be recorded for a single year, there is little doubt that a revelation of sickness and death from this cause would be produced only a little less astounding than that arising from poisoning with sewer gases. There are but few individuals who cannot refer to well-authenticated instances where illness affecting a household has been traced to the water cistern. It may be that the decomposed remains of a dead bird, mouse, or rat is found in the cistern, and that the mysterious illness disappears after the cleansing which then ensues. Even decaying vegetable matter, such as leaves, or the successive

* The data for this table are taken from the 6th Report of the Commissioners appointed to Inquire into the Pollution of Rivers.

generations of vegetable growths which occur in some water mains and cisterns, are not unfrequently the source of distressing maladies, and although the necessity for scrupulous precautions to secure a pure water supply from the household cistern has been urged from time to time, yet, like many other things which are not apparent at first sight, do not obtrude themselves on our senses, no attention is paid to the subject. Things which can be seen, or discovered by the palate, at once arouse suspicion and vigorous action. Many of us would be up in arms if we found our milk watered, or our coffee mixed with chicory; but from a sanitary point of view these are venial matters compared with impure water. Daily we are in the habit of straining at the gnat and swallowing the camel in sanitary matters, and not the least in this matter of household water.

It is our object now to consider generally the various methods hitherto used for filtering water for drinking purposes in the household, and in a very brief way to examine how far they meet the requirements. All existing types of water filters may be classed under two heads: (1) *Mechanical filters*, which separate mechanically suspended solid matter from water. (2) *Chemical filters*, which have the property of removing certain bodies, such as albumen and some salts, in a more or less perfect state of solution, in consequence of a specific attraction which some bodies possess, depending on their molecular constitution, or, chemically speaking, on the particular kind of matter which forms the filter, such action not depending on the size of the pores. Mechanical filters remove the solids, because the pores are too small to permit anything but liquid to pass, and they have hitherto been made of textile or felted fabrics of every description, the pores of which are fine enough; coarse pottery or earthenware in the biscuit or unglazed state; sandstone, in various forms, particularly that called dripstone; carbon diaphragms or blocks formed of powdered coke, cemented together by means of carbon deposited by heat from sugar or tar in closed moulds; wood in thin sheets; leather; layers of finely-powdered substances, such as glass, sponge, and, perhaps most effectual of all, paper. It is not necessary to enlarge on this class of filters. Chemical filters for animal charcoal and spongy iron are the principal chemical filters employed.

The annexed analytical tables, showing the effect on the organic impurities by employing animal charcoal and spongy iron respectively, have been taken from the 6th Report of the Rivers Pollution Commissioners. It will be seen that the organic constituents of water, even that which has already been filtered through a sand filter, undergoes a further very considerable reduction with both spongy iron and animal charcoal. The spongy iron is used in porous blocks, and the animal charcoal in coarse grains, and the water is passed through a small vessel filled with it. The great defects of these filters are that (1) they are bad mechanical filters, and (2) the water has to pass through the accumulated impurities of many months, and in the case of animal charcoal, owing to the presence of phosphates in large quantity (animal charcoal consisting of charcoal 10, phosphates, etc., 90), it is very favourable to the growth of low forms of vegetation and afterwards animal life. In the 6th Report the Commissioners state: "Indeed, we found that myriads of minute worms were developed in the animal charcoal and passed out with the water, when these filters were used for Thames water, and when the charcoal was not renewed at sufficiently short intervals. The property which animal charcoal possesses in a high degree of favouring the growth of the low forms of organic life *is a serious drawback to its use as a filtering* medium for potable waters." It has been found in consequence of the accumulated impurities that when water is passed continuously for a long period through such porous masses, that at length the water will actually be further polluted in passing through the filter.

The essential requirements of a good household water filter are: (1) It must be a perfect mechanical filter. (2) It must be an active chemical filter. (3) It must be easily accessible for examination and cleaning. (4) It should have sufficient filtering area to supply the necessary quantity of water without delay or inconvenience. (5) The filtering medium should be replaceable with great facility, so that there should be no excuse for neglecting this precaution. (6) The arrangement should be such that nothing but pure water could be conveniently used, either for cooking or for drinking. The author having these objects in view, has endeavoured to meet all the conditions in the following way: the filtering medium

COMPOSITION OF WATER BEFORE AND AFTER FILTRATION (IN PARTS PER 100,000).

ANIMAL CHARCOAL.

DESCRIPTION.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Chlorine.	Hardness.
Grand Junction Company's Water, Unfiltered	·129	·023	0	·188	1·60	19·1
Filtered.....	·029	·007	·013	·191	1·60	15·2
Grand Junction Company's Water, Unfiltered	·161	·030	·002	·062	1·90	19·7
Filtered.....	·010	·002	·002	·125	1·90	19·1

SPONGY IRON.

DESCRIPTION.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Chlorine.	Hardness.
Before filtration.....	·122	·015	0	·152	1·90	20·3
After filtration.....	·028	—	·070	0	1·90	8·9
Before filtration.....	·230	·017	0	·235	2·20	21·5
After filtration.....	·060	·008	·008	0	2·20	11·8

employed consists of thick sheets of filtering paper, the peculiarity of which is that, instead of being made of ordinary paper pulp alone, a quantity of pure animal charcoal, freed from phosphates by washing with acid, is added to the pulp before it is formed into sheets. From 10 to 20 per cent. of this paper consists of purified animal charcoal. This special paper is used in a small filter press, worked by means of the pressure in the main service pipe, either in the basement of the house where the water comes in, in case of constant service, or else in the service pipe from the supply cistern in the case of intermittent service. By an inspection of the specimen filter shown, the arrangement of the filter will be readily understood. The filter press employed for this purpose, and which is shown as mounted for use, consists of a series of grooved plates on which the diaphragms are supported. The grooves in the filter plates forming the drainage surfaces, each plate has both surfaces grooved or channelled, and provided with the prepared carbon paper. These plates, with their filtering papers *in situ*, are kept apart from each other by an open frame or distance ring, and thus a battery of

filtering cells is made up, when the series of alternating plates and frames is screwed up between the fixed and loose heads of the machine. Passages for inlet and outlet are formed in the metal of the plates and frames, and suitable ports are formed so that the supply ports shall be in the distance frames conducting the water to be filtered between the paper linings of the filtering cells, and outlet ports conduct the filtered water into the common outlet channel from the grooved plates. The method of forming the internal channels in a pressure filter was originally devised by Danck. Fig. 1 shows the filter mounted against a wall filtering all the water in a service main. Fig. 2

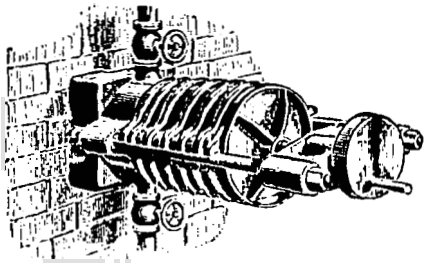


FIG. 1.

shows the filter mounted vertically, where it may be more convenient to draw off in front in that position. When it is desired to change the carbon papers for fresh ones, the filter can be shut off on both sides from the service pipe by means of the two valves, the main tightening screw can be loosed, then all the papers become free to be removed and replaced, which is only the work of a minute or two. When screwed up the machine is again ready for work. We thus have (1) a good mechanical filter of paper with the pores filled in with fine carbon; (2) a good chemical filter with the carbon in it ten times more concentrated and

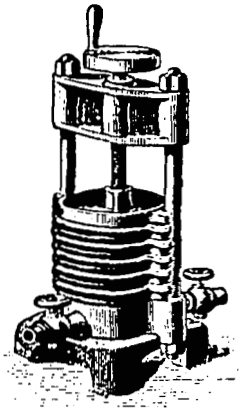


FIG. 2.

more active than ordinary animal charcoal in grains in consequence of its being deprived of the phosphate of lime, and by the absence of which it is no longer capable of favouring the growth of the animal and vegetable organisms, which are the chief danger of the phosphatic animal charcoal in grains (3) Nothing can be more simply accessible for cleaning, all the parts being released by means of a single screw. (4) The filtering area, even in a small apparatus, is very considerable. A machine with 6 plates has 12 filtering papers, and these working under the pressure of the main admit of the water being drawn off as required, without the necessity of the objectionable practice of keeping a store of filtered water (5) The filtering medium in the form of these thick paper discs can be changed with the greatest facility. By this means passing the water to be filtered through the accumulated impurities of a long period is easily avoided. No doubt, the masses will have to be educated to a knowledge of the impurity of the water they drink, and the vast amount of disease and suffering in consequence, and then it will not be thought superfluous to pay daily attention to secure clean drinking water. I had hoped to be able to give you some practical results of the working of this system, and the analytical results of the water before and after filtration, but it has not been found possible to accomplish this. But with the permission of the Society I may have an opportunity of making a short communication at a future time on this subject.

DISCUSSION.

The CHAIRMAN said they had to thank Mr. Johnson for bringing forward an excellent method of applying the filter press to drinking water, but with regard to the general question one must remember, in justice to the much-abused water companies, that the health of London did not seem to suffer from the river water, in fact, it might be open to question whether sufficient area, especially with the presence of vegetable growth, did not afford as much safety from serious pollution as wells—at any rate unless they were extremely deep; and judging from a case which had occupied the law courts recently there seemed to be two sides even to the deep-well question. Whatever the water supply, it was necessary that it should be filtered for the purpose of drinking, and there was in this system a very perfect means of doing so, perhaps not so perfect as the combined chemical mechanical action of the Porter-Clark process, but one infinitely superior to the average of filters, some of which he had examined from time to time, and found they did not require a more delicate test than the nose to discover that the water was much better before it went in than after.

Sir FREDERICK BRAMWELL said it might interest the meeting to know, with regard to the case referred to in the paper of the pollution of water at Caterham, that there was one convincing proof of the theory advanced, and that was this: a portion of the district supplied by the Caterham company nominally was free from the disease, and it was asked how could that be if the disease was due to the water, but it turned out that that particular portion of the district was for a time supplied by another company, and, so far as the mains were supplied by that other company, there was no disease, whilst those supplied from the well in which that wretched man committed the filthy act mentioned the disease was rampant. That it must have arisen from the water was also clear from another fact. A lady drove over to Redhill, and while she paid a call there, and left her carriage standing in the town, the coachman got down and drank from the public drinking fountain, went home, and in a few days was dead. It could not therefore be anything in the locality, since here was a fatal result to a stranger who was only in the place perhaps half an hour. One must remember that this had really nothing to do with the question of deep well water or not. The water so-called, which had been supplied many years before, and many years since, was amongst the purest of the deep chalk waters, and the evil arose from an accident in one sense which might have befallen the New River. It had nothing to do with the source of supply. The general question had been touched upon in a way which was often done, and a great deal had been said about the iniquity of London water companies. Now, in the autumn of 1883, whilst travelling in the United States, he made it his business in every town to

which he went to inquire about the water supply, and he was assured by all the engineers to whom he spoke, with one exception, the village of Poughkeepsie, that there was not a single instance of the water being filtered before it was supplied to the towns. When he asked how that was, he told him that they all had filters in their own houses. Then he asked about the poor people, and those who lived in tenements, and those who had not filters, and he replied that they had not thought about them. He told him that if ever there was an epidemic of cholera there the loss of life would be something frightful. In New York the consumption of water was 80 American gallons (equal to 64 English gallons) per head per diem, but the population had so grown, and the mains were so overtaxed, that the terminal pressure was next to nothing, and you saw in the shop windows hydraulic engines to be put into the basements of houses, to be worked from the feeble pressure from the mains in order to pump up the balance of the water to the top of the building. That was how it was dealt with there, because they dare not enforce proper fittings on the customers, because the popular voice did not like it. In Boston the water was so abominable that every person of respectability purchased it from a private company who brought it round in casks. To come back to London, there was an unimpeachable source of supply in the Kent Waterworks, and he thought also an unimpeachable source in the New River. They had heard tales about the intake of the New River which proved to be untrue, and with regard to the supply from the Thames, chemistry had failed to indicate any source of disease. Dr. Frankland said so far as he knew no harm arose from drinking healthy sewage, but, of course, if any outbreak of disease arose it might be that evil would follow. Were they to buy up the present companies? In that case he supposed a miracle would happen, as had constantly happened before. You might go into a committee room in the House of Commons and find a number of gentlemen there, including the town clerk and mayor of the town, declaring that of all the vile supplies of water in creation the one supplied by the company was the worst; then they brought forward the joking witness, the scientific witness, the oldest inhabitant, and so on, and at last they made such a dreadful case that the committee suggested to the company, had you not better agree with the corporation. Then they went out into the lobby and came back and said it was settled. The corporation acquired the undertaking, and without any change of any kind, except the mere fact that the company was purchased by the corporation, that dreadful water, which was not fit to be drunk, or even to be looked at, became proper water for the town to drink for ever afterwards. That was a miracle of very frequent occurrence, and he supposed the same thing would happen in London. It might be said that he was only airing the fallacies of Mr. Easton and Mr. Bazalgette, but that fallacy was this: There were used for all purposes, in London, 32 gallons per head per diem, including waste of all sorts, a great deal of which arose from bad fittings, and they were allowed to exist because of the outcry which would arise if they attempted to enforce the use of good fittings. By no possibility could the people use more than two gallons per head per diem for potable and culinary purposes. The experiment had been carefully made, and therefore with four million persons in London the necessary supply for those purposes would be eight million gallons per day. People at once said, What, would you have a dual service, with all the terrible expense and complication? In other towns it was done, in Paris there was a triple service. To his mind the mistake was in not keeping water for potable and culinary purposes separate. The water for watering the roads and so on did not require to be of such absolute purity, and he thought it would be extremely well at the cost of some five millions to appropriate the chalk water supplies to cooking and drinking purposes by a separate system of mains, and to use the other water, which was quite good enough, for all other purposes. The question would then become very simple. There was ample water in the chalk for drinking purposes for a London of double the size, but he did not think there was ample water in the chalk within a reasonable distance for the supply of the whole metropolis under the present system. Then he would suggest that this dual supply should be made use of for the purpose of extinguishing fires, and this was by no means so absurd as some people seemed to imagine. The whole of the water used in London for extinguishing fires amounted, according to his recollection, to about a day's supply. It was said that it would be using the most expensive water for extinguishing fires, but that would not matter. They could afford to pump eight million gallons of water a day against a head of 400ft., and with that head and a proper system of pipage they could contribute the greatest quantity of water ever wanted for the greatest fire ever known, taking Captain Shaw as an authority.

A MEMBER asked if Mr. Johnson claimed that the filter press would take out germs from the water, and if so how he arrived at that conclusion, because he had already stated that he did not know what the germs were.

Mr. JOHNSON, in reply, said he had stated in the paper that the object was not to take the germs out, and no one could say that it did. The principal thing was to remove organic matter, because it was found, whether the disease proceeded from germs or merely from some specific poison, it was always associated with organic matter. That was the reason why animal charcoal was introduced into the filtering paper. Further, the removal of phosphates was an important matter, as it deprived the lower organisms of the food necessary for their existence, and therefore there was not the opportunity of the accumulation of a mass of decomposing organic matter in the filter itself. With reference to the fact stated by the President, that London was very healthy, he would simply remark that it might be healthy as compared with other towns, but still it was not so healthy as it would be if perfectly pure water were supplied, because there was a great deal of disease resulting from the drinking of bad water, as could be testified by any medical practitioner.

NOTES ON KIESELGUHR AND ITS TECHNICAL APPLICATIONS.

BY A. HAACKE.

KIESELGUHR, or infusorial earth, is a white, gray, or greenish powder of very low specific gravity, consisting chiefly of the minute silicious shields of diatomaceæ, the beautiful and varied forms of which will be known to everyone familiar with the use of the microscope. Large deposits of fossil diatoms have been traced in many parts of the world, and several mines producing kieselguhr are worked in Europe, but the largest, and those yielding kieselguhr of the purest quality and lowest specific gravity are situated near Naterlouss station, on the railway from Hamburg to Hanover The kieselguhr is found there from the surface down to a depth of about 150ft., being covered only by thin beds of diluvial and alluvial origin. The upper stratum of this large deposit supplies the white kieselguhr