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### PURIFICATION OF WATER FOR BARRACKS, PRISONS, AND OTHER INSTITUTIONS.

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(FELLOW.)

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THE subject which has been selected for discussion this evening and which I have the honour to bring before you, is one that interests us all. As you see from the heading of the paper, it is "The purification of water for barracks, prisons, and other institutions," and at first sight this title might seem to limit my observations to what is called domestic filtration. But wherever we deal with barracks and other institutions we require something more than ordinary domestic filtration with which to purify water, and we really have to consider the whole question of water purification.

Let me state at starting that it is absolutely necessary, as I shall show later on in quoting some experiments I have made, that from whatever source a water supply is taken that source should be above suspicion. I think that no system of purification that we can adopt will render a water supply under all conditions perfectly safe. Take for instance filtration on a large scale; we have got influences of climate, influences of frost, and conditions regarding organic matter in the water to deal with. And again, when we employ filtration on a small scale we have got other circumstances to consider which I shall have to refer to afterwards.

Now first and foremost I shall to-night treat the subject of filtration more with reference to institutions and barracks than on a large scale. The latter subject has been sufficiently, and perhaps exhaustively dealt with by others, so I shall limit

what I have to say simply to barracks, prisons, &c. Now, a suspected water is generally purified by filtration, either on the ordinary non-pressure system or with pressure. Filters may be divided, then, into those which are used with pressure and those which are in use without pressure. Now of the most common filters in use without pressure perhaps animal charcoal is that which has been up to the present used more than any other substance. Animal charcoal, as you know, is a substance procured by burning bones; it has the power of condensing oxygen within its pores; one cubic inch of animal charcoal takes up as much as ten cubic inches of oxygen and condenses it. Charcoal holds this condensed oxygen within its pores to oxidise any organic matter which may be present in the water. Organic matter, as you know, is composed of carbon, hydrogen, nitrogen, and sulphur and the oxygen in the charcoal has the effect of oxidising this organic matter. Animal charcoal simply changes the nature of the organic matter and is said on that account to render it harmless. If this were all that was needed, animal charcoal would to a large extent fulfil the purpose required of it. But something more is added besides oxygen; animal charcoal contains phosphates and nitrogen, and I have no hesitation in affirming, from experiments, that it forms an admirable breeding ground for micro-organisms; certainly the number increases after passing through animal charcoal, and we consider it, therefore, an unsafe medium for water filtration. It also has another objection—that vitalised, *i.e.*, fresh organic matter passes through animal charcoal and appears to go through it unchanged. Dissolve albumin in a portion of water, pass it through animal charcoal, and what is the result? It passes through almost unchanged. But if you allow that organic matter to decompose, if you allow a certain amount of decomposition to be set up, the animal charcoal appears then to remove the greater part of it, at least so far as we can judge by chemical analysis afterwards. So much for animal charcoal.

The next and perhaps the substance most in use after charcoal is spongy iron—*i.e.*, hæmatite ore heated short of fusion—which appears to exercise its purifying mission from the fine state of division in which it exists. When water is passed through spongy iron it is broken up, being acted on chemically, the hydrogen is given off, and the oxygen goes to oxidise the organic matter in exactly the same manner as animal charcoal. Spongy iron removes on the average from 40 to 50 per cent. of the micro-organisms, but increases the free ammonia, and also has a tendency to cake, and the water then passes down between the sides of the vessel and the filtering medium. Unless it is kept constantly wet this is very liable to occur. It also adds iron to

the water, which is subsequently got rid of by means of black oxide of manganese, sand, gravel, etc., and unless these are carefully handled they all get mixed up together, with the result that the removal of the iron from the water is rather imperfectly done. The chief objection to spongy iron is that it does not sterilise water. Again, we have in use those filters which are seen in the Navy, the filtering medium being composed of carbon, ferrum, and albuminum, the name carferal is given to it. This has also the objection that although it does not add anything injurious to the water, it does not sterilise the water. In fact I hardly know any small filter suitable for domestic purposes—I know of no substance that will sterilise water, if non-pressure filters are used. The filters we come to are pressure filters; for example, the Pasteur-Chamberland and the Berkefeld filters. The Pasteur-Chamberland filter is made, as you know, of china clay in which the pores are extremely fine. Now in every experiment that I have made the Pasteur-Chamberland filter has sterilised water. I have never found an instance in which the filter failed, except upon one or two occasions when a personal error entered into the experiment. The difficulty about the Pasteur-Chamberland filter is generally in connection with the joints, and where we have to deal with it, for military purposes at least, this forms one of the chief objections to that filter. In the system the liability there is to fracture when carrying these filters about, the difficulty of plugging up the holes afterwards, and the slowness of the rate of filtration tend rather to limit the usefulness of the Pasteur-Chamberland filters for military purposes. On the other hand, for barracks and perhaps for other institutions where proper supervision can be carried out, where they can be put up and have not to be moved and plenty of time can be given for filtration of the water, they are, I believe, one of the best class of filters that we have at the present day.

One or two points in connection with the Pasteur-Chamberland filter are important. If you look at one when it is broken across you will find that the thickness of the material is not perfectly even; well, that is a defect in making, and there is no reason why it should not be overcome. My own idea is that we should get a much more rapid filtration, and perhaps equally good, if the material were not quite so thick as it is in the bougies, which are generally supplied in filters of this class.

The Berkefeld filter also sterilises water, and I may say of it that under no circumstances have I found that filter to fail. It is more rapid in its delivery than the charcoal filter, but for military purposes it is perhaps not so good as the Pasteur-

Chamberland filter. It is more friable, more likely to break and less easy to clean.

The great difficulty we have with these filters is in regard to this question of cleaning and keeping them in order. It may be possible in civil life, in prisons, and in institutions of that sort to get a man or one or two men to acquire a knowledge of the circumstances under which they may be used, to learn how to clean them, how to regulate them, how to keep them in order, so that they may always act as they ought to do. But in military life it is extremely difficult to get soldiers to do this sort of work; they are constantly on the move, constantly changing from station to station, and are utterly careless, if I may say so, as to whether water is filtered or not. It would be extremely hard to get them to give the attention to these filters which is absolutely required. Again, except where public water supplies are to be had we never can use these filters because they require pressure, I may say constant pressure, in order to drive the water evenly through them so as to obtain the best results. I may add that the pressure must not be excessive, because if the pressure be too great we find that in time the micro-organisms themselves are driven through the filters.

These two classes of filter have no chemical action on water, they simply sterilise it; they do their work well, and if proper attention is paid to them they seem to afford every security so far as water is concerned. If, however, you are dealing with the class of water you get abroad, water quite different from that which you get at home, where there is a large growth in the water of *desmidiæ* and *diatomacæ*, rapidly flourishing under a high temperature, these filters get coated and in a comparatively short time the water ceases to pass through them. Of course, this could be obviated by constant cleansing of the filter. These filters furnish us with the means we have for purifying water at the present day.

I have not gone into the question of sand filters, which most of you know of, because it is rather in connection with large town supplies that they are used. However, in smaller districts, for schools, barracks, and prisons, a sand filter often proves invaluable. I know one institution not a hundred miles from London in which a sand filter was put up some years ago by Mr. Rogers Field, who is well known in the Sanitary Institute, which has worked perfectly and from which the water issues nearly sterile. It has a most admirable purifying effect upon the water which passes through it.

There is one point in connection with this subject which I should like to impress upon you all, and that is that there should be no duplicate water supply in any place. Where you get two

systems of water supply, one filtered and one unfiltered, you are always in danger of something occurring. Ordinary individuals will not distinguish between one tap and the other, and such a system is certainly to be deprecated. Again, may I say that the placing of a number of small filters for any institution is not to be commended. The multiplication of filters is a thing which we all decry. It is one of the evils of the olden days when filters were upon every landing almost in every barrack, never taken down and supposed to last for a lifetime, adding impurity to the water instead of removing it. The water supply to large institutions, to barracks, prisons, hospitals, and other places in which there are a large number of people congregated ought to be supplied filtered on a large scale and fit for drinking, and as far as I know the best means of filtering on a large scale is certainly through sand. I have seen this on several occasions and in many places. A sand filter properly constructed, properly laid, with sufficient depth, and the rate of flow through it so guarded as not to be excessive will yield water as a rule pure, unless at the source the water is in an exceedingly bad condition. Sand will certainly render ordinary water potable in the majority of cases. But there are certain conditions in which we cannot depend upon filtration at all; such conditions are seldom to be found in civil life, but are frequent in military service, and the means of dealing with them may be at times useful in civil life.

Now, is it possible to add anything to water that will render it absolutely sterile? Is it possible under our present knowledge of infectious disease to render water sterile without submitting it in any way to a filtering action? I have been lately making some experiments with regard to this, and they have been so far as I have gone eminently successful. But I found certain conditions and certain things occurring during this series of experiments which perhaps increase one's knowledge of the whole subject. In Germany a few months ago—eight or ten months—it was suggested to sterilise a suspected water with a solution of bromine, and afterwards to decolorise it by using a solution of hyposulphite of sodium. I have made a series of experiments to test this sterilising action of bromine, as it would be invaluable in many cases in which filters failed, or in which filtration was not possible. I won't weary you by reading over the details of all those experiments, which I have here, but they were done very carefully, under conditions which I think admit of no fallacies. The idea of the experiments was to place a certain quantity of typhoid bacilli (*Bacillus Typhosus*), in water after incubating it in a bath at a certain temperature, to try whether by the addition of a certain quantity of bromine,

you could sterilise that water. (a) 100 cc. of distilled water were placed in a sterile flask and one loopful of a growth of *Bacillus Typhosus* added, and diffused in the water. After incubating the flask at 37°C. for 48 hours a gelatine plate was made with 1 cc. of the water and incubated at 22 degrees C. (b) .2 cc. of the working solution, that is, .06 grammes of bromine per litre, was then added to the flask. At the end of five minutes the water being still coloured with the bromine solution, a gelatine plate was made with 1 cc., and incubated at 22 degrees C. At the end of 48 hours plate (a) showed numerous typhoid colonies, plate (b) was sterile. After incubation for 7 days plate (a) had become crowded with colonies, but plate (b) showed no growth, and has remained sterile up to the present day. Plate (b) was the one treated with bromine. This experiment was made with distilled water. I then made a second series of experiments with stream water, that is, a water highly polluted. The *Bacillus Typhosus* was added to the stream water and incubated at 37°C. for 48 hours. A gelatine plate was then made with  $\frac{1}{2}$  cc. (plate a). To 100 cc. of the stream water and *B. Typhosus* .2 cc. of the working bromine solution was added and incubated for 48 hours; after five minutes a plate was made with  $\frac{1}{2}$  cc. (plate b). The incubation was continued for several days; plate (a) rapidly liquefied, and plate (b) treated with the solution showed after a week's time only one mould and a colony of *Proteus Vulgaris*.

Then it occurred to me that it was possible the organic matter and free ammonia in the water had so reduced the strength of the bromine that they actually prevented its acting in such dilute quantities as I had hitherto worked with. I therefore made a further experiment, by taking a series of working solutions, and adding them to artificially polluted water, making a chemical analysis at the same time. I found that what I had suspected had really occurred, *i.e.*, that the organisms present in the water and the organic matter required more bromine solution than I had calculated on, and by increasing this to a very small extent I found that I sterilised the water completely.

The following experiment was arranged to test the power of bromine on a water containing *B. Typhosus* and artificially polluted with broth (non-sterile): four sterile flasks were taken and into each 100 cc. distilled water, 2.3 cc. broth, and one loopful of a growth of *B. Typhosus* were placed. The flasks were labelled (a), (b), (c), and (d), and then incubated at 37° C. for 24 hours. The next day, for control purposes, gelatine plates were made with one cc. of the contents of each of the flasks, then—to flask (a) .2 cc. of the working solution of

bromine was added (·06 gr. per litre); to flask (b) ·3 cc. of the working bromine solution was added (·09 gr. per litre); to flask (c) ·5 cc. of the working bromine solution was added (·15 gr. per litre); to flask (d) ·6 cc. of the working bromine solution was added (·18 gr. per litre). At the end of five minutes gelatine plates were made with one cc. of the contents of each flask. All the plates were incubated at 22° C. The first series of plates, i.e., the control plates, rapidly liquefied; the second series showed no growth for 48 hours; after 72 hours liquefying colonies appeared in the plates from flasks (a) and (b). After 96 hours the plates from flasks (a) and (b) were liquefied, but the plate from flask (c) showed only one colony and flask (d) remained sterile. After seven days' incubation the plate from flask (c) still showed only one colony, and the plate from flask (d) still remained sterile. I made a chemical analysis of the water with which I had been dealing, and the result of that chemical analysis showed that it contained 3·753 parts of free ammonia per 100,000, and 9·5 parts of albuminoid ammonia per 100,000, that it was more highly polluted than a water one would be likely to get from the effluent of a sewage farm.

Now from these experiments it appeared that bromine, present to the extent of ·06 grammes per litre, would destroy *B. typhosus* when present in a water polluted to a greater extent than a sewage effluent or any water that is likely to be used for drinking purposes. Having arrived at this result, the next point I had to deal with was how to get rid of the colour and taste of the bromine. This was done by adding to each litre of water containing the ·16 grs. bromine, sodium hyposulphite 0·095 gramme and sodium carbonate ·04 gramme. The colour immediately disappears; the water had a pleasant sharp taste, and no odour of bromine whatever could be detected in it.

In mentioning these experiments, there are one or two things which strike one in them. We often hear about the antagonism which exists between chemical and bacteriological examination. In truth, one helps the other; one is largely dependent upon the other. I could not help noticing in these experiments—I have only quoted the results of a few of them here, they numbered upwards of 40 altogether—how much the presence of organic matter in the water influenced more or less the growth of the pathogenic forms in that water. In perfectly pure distilled water the *B. typhosus* appeared to have no power of multiplication whatever; but if you added to that water a broth culture, i.e., if you made that water impure, and gave to it the characteristics of polluted water, the bacilli not only remained in the water but appeared to increase in number.

. We often hear it said that a chemical analysis gives us no indication; I think on the contrary it gives us a very excellent indication; it tells us under what conditions a specific organism introduced into water is likely to spread, multiply, and propagate itself. In pure distilled water, a water which we call chemically pure, these organisms do not appear in any way to increase; whether they die out or not I am not at present quite certain. Certainly they do not appear to increase as far as my observations go, and it shows us that after all we must rely to a large extent on chemical analysis to show us the condition of the water, and on bacteriological examination of the water to define what the organic matter really is, whether it is due as it may be to animal life or simply to vegetable material.

Now, this principle I have tried to explain to you to-night is one which has been exercising our thoughts a good deal lately on account of the excess of enteric fever in India, where it is impossible to resort to the system of filtration and those means of purifying water which we find here in England at the present day. If we can, by adding to water some such solution as I have here foreshadowed, and render that water sterile, I think we may perhaps to a certain extent reduce the mortality from that disease in India and other tropical countries where it has proved so fatal.

There is another method which is being introduced—I am not sure by whom—and I have been making some experiments with it also. It was suggested to me as coming from Vienna last year; it promises results, but certainly they are not so good as those I have already mentioned. I allude to calcium hypochlorite. The great difficulty I have found with this substance is its insolubility. Water, containing .02 grs. of this substance per litre, was seeded with *B. Typhosus*; plates were made and incubated and remained sterile after seven days. The experiments which I made may be briefly summed up as follows: *B. Typhosus* was placed in distilled water and incubated 24 hours at 37° C., plates were then made and numerous colonies of *B. Typhosus* grew after 48 hours' incubation; calcium hypochlorite was then added in the proportion of .02 per litre; 15 minutes later plates were made and incubated at 22° C. and the plates were still sterile after 10 days' incubation.

The third series of experiments was: water polluted with broth, seeded with *B. Typhosus*, and incubated at 37° C., it became crowded with colonies; calcium hypochlorite was added and after 15 minutes plates were made, and no growth has yet appeared on the plates, although they were made 11 days ago. These experiments are very recent and I do not know whether the plates will remain sterile for any time. I should be sorry



to accept the results yet, and simply give them as perhaps somewhat a new departure in the lines of purifying water.

Now, I pass on from this method of chemically—if I may so call it—sterilising water to that system which is one of the oldest and well known to you all, that is, submitting water to the action of heat in some form and thus sterilising it. From my own experiments, I think that water can be sterilised for all practical purposes without boiling it. My colleague, Professor Wright, has been making some experiments upon the typhoid organism. I have been doing the same. We both have found that in making the typhoid vaccine you can destroy the organism at a temperature somewhat between  $60^{\circ}$  or  $65^{\circ}$  C. I now think it is not necessary to quite boil the water. I am perfectly satisfied that if it is raised to  $60^{\circ}$  or  $70^{\circ}$  C., as regards the micro-organisms of cholera and enteric fever it is practically rendered sterile. The plan which has been in use in military life for military purposes generally, and also in many civil districts—as at Maidstone—has been simply to boil the water, and perhaps after all there is no simpler, no surer, and no better method, if people will only do it, than simply to boil water to render it sterile. But boiling takes time, and when you have to deal with the community at large you will find that they do not often wait for water to come to the boil. And as far as soldiers are concerned, the soldier is very apt to stick his mug, or whatever vessel he has, into the water and take it away long before it reaches the point at which water is rendered safe.

There have been one or two methods of late introduced. I have no practical experience of them; they are under investigation now. In this direction, Monsieur Desmaroux's apparatus, which may be seen in the corridor of the Museum, is under investigation at Netley for the War Department, but we have been unable to make any experiments with it yet. However, his principle is sufficiently interesting, to allow me to mention it here, although I have no practical knowledge of its results, or of what it does. It simply consists in taking water at a certain pressure, and heating it in caissons to a temperature of about  $100^{\circ}$  to  $120^{\circ}$  C. as required; the incoming water cools the water passing out, and obtains a certain amount of heat before passing into the caissons. Now, the great advantage of this, as far as one can see, is the rapidity with which the sterilisation—if the water is sterilised—is performed. I have no reason for saying it is not sterilised, because I have no practical experience of it. But from the experiments which have been made, the results of which have been placed in my hands, it appears that it does sterilise water. The great advantage is the rapid

delivery, and as far as we in military service require water, the system is no doubt a sound one and the principle upon which it is worked good. One can state as far as I understand it that none of the dissolved gases in the water escaped; the water certainly that I tested appeared to differ in no way from that which went into the steriliser; it was apparently as well aerated, as far as physical characteristics could be discerned, as that which went in; but I have no further knowledge as to whether it absolutely sterilises water. Knowing, however, the conditions under which pathogenic organisms can be sterilised in water, I think there is no doubt, if it is submitted for 7, 8, or 10 minutes to the temperature of  $100^{\circ}\text{C}$ . to  $120^{\circ}\text{C}$ ., it is rendered comparatively sterile and free from danger. But I cannot speak with more certainty of it than this, because the matter is as far as I am concerned *sub judice*, but it appears to me that it supplies a want which we all have up to the present experienced. For I confess honestly that of all the questions that have bothered me for years past the most difficult one has been the purification of suspected water supplies, where we have young men, such as soldiers, to deal with, depending possibly upon sources which are anything but advisable.

With these few brief observations I venture to place the subject before you, in the hope that it will lead to some discussion; for it is a subject which interests us all, a subject which at the present day stands, I may say, almost in the forefront of sanitary work. We see around us day by day a number of cases of enteric fever; one cannot help noticing that even here in London there is more enteric fever than there ought to be. Anyone who has studied those admirable charts which the medical officer for the County of London, Mr. Shirley Murphy, has prepared, cannot fail to see that there is a very close relationship between the increase of enteric fever, or at least its prevalence, in London, and the conditions of the water supply. I hope that someone who has had practical experience of this very interesting subject will enable us to come to some broad conclusions with regard to it and help to diffuse useful information.

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REV. F. LAWRENCE (Westoe Vicarage) said he was the Chairman of a Council in the East Riding, and their small village suffered from inferior water. He was Vicar of that parish and Hon. Secretary of the Church Sanitary Association, whose object was to aid the clergy in taking an active interest in sanitation. The Church Sanitary

Association sought to teach the necessity, *inter alia*, of a pure water supply. They had had a magnificent sermon that evening, and he wished it could have been delivered in every cathedral, in every church, and in every chapel in the United Kingdom, and indeed wherever English was spoken. If it was wrong for parents to neglect the education of their children, it was worse to give them water to drink which might kill them. There was a moral responsibility in regard to a pure water supply, and this truth ought to be driven home by every minister of religion and every teacher. The Founder of their religion cared as well for the body as the soul, and this concern for the temporal welfare of the people manifested by the Christian Church was increasing in influence in every part of the world. It was to be hoped that all Christians would be taught that it was their duty to care as well for the body as the soul.

Mr. WOLFF DEFRIES (London) remarked that he had little to contribute to the discussion, if discussion were possible on a paper in which so much must commend itself to those who had any experience on the subject. He had listened to Professor Notter with considerable edification, for the paper gave in practical form the net result of many things which had been floating in the air. As to the practical possibilities of the Pasteur filtration on a large scale, which he was in a position to discuss from a technical point of view, he thought that they had not quite said the last word on the subject of this class of filtration. It had been the constant policy of those who, both in France and in this country, were concerned in introducing that method, after having once successfully contested their patents in the courts of law, to refrain from preventing the use of any cognate materials which might infringe those patents, in order that a patent should not affect so important and vital an interest, placing the whole community upon the intelligence and efforts of one set of men. It was therefore possible that analogous filters to the Pasteur might arise and present its advantages in even an improved form. He thought, however, that bacterial filters in their present form were adequate to the purposes contemplated by the paper. The defects to which Professor Notter had alluded mainly referred to the mechanical construction of the filter cases, and had been remedied by now. For instance, the question of joints. When Professor Notter spoke of the joints, he doubtless had in his mind the portable and not the fixed form (Professor Notter: Quite so.) As he knew the man who made the portable joint, and the circumstances under which it was made, he thought he might say that the joint was an improvisation made under urgent demand and was decidedly unsuccessful, but there were obvious means of making a joint of a filter of whatever size sound and practicable. Then slowness was urged against this class of filter; but he had never known it to arise except from one cause—the attempt to get a higher duty out of the filter than the nature of the water allowed. If they had regard to the nature of the water and put in a filter of a proper size, his own experience was that with this class of filter any quantity of water could be got,

and that there would be no trouble in the working. In India, from reports that were continuously sent to him, the use of these filters had extended enormously. A number of jails had adopted this particular system and it had worked efficiently, satisfactorily, and without trouble. He mentioned this result not so much in criticism of the particular apparatus that happened to be installed, as an evidence of the fact that when installed by competent persons with due regard to size, bacteriological filtration gave a serviceable and practical result. He desired before passing from the subject of filtration to offer a word of caution. The manufacture of a bacterial filter is at present a purely empirical business. The substance used is a complex mass of various materials, and is not merely china clay; and it requires the highest skill in pottery to produce a uniform result in respect of sterilising capacity. It was the difficulty of obtaining a trustworthy result which accounted for the fact that Pasteur tubes, for example, have up to now only been produced in the cylindrical form, great as the temptation is to produce them in other forms. When they heard from Professor Notter that Pasteur filters which will be found invariably sound can be produced one after another it did not mean that this occurred by accident or was a simple matter. It was due to a constant sedulous supervision, an accuracy of manipulation, exercised under the control of a master potter who had made the subject his special study for over fifteen years: and with all this skill some thirty per cent. of the finished tubes were rejected on test. In contemplating a possible alternative, it was therefore of quite as much importance to have adequate guarantees of this inflexible and competent control as to obtain an adequate intrinsic efficiency in the material itself. He could not conceive anything more disastrous to the progress that has undoubtedly been made in water purification than the admission of possible alternatives to satisfactory methods on the ground of laboratory examination of individual examples that were satisfactory, without obtaining complete evidence that such control in manufacture was exercised, and that the articles supplied in general commerce were identical with those furnished to laboratories and to firms who habitually supply laboratories; and while personally he felt every desire that this industry should prosper and extend to the creation of other types of the same kind, he felt that it was only on that condition that it could do so. He had spoken much longer than he intended, and could only attribute it to the fact of the suddenness with which he had been called upon. In the language of some old French writer he could say that if he had had more time to think it over he would have spoken at less length. The point for him as a practical man was, supposing he had a water supply for an institution or a field expedition to fit with an apparatus for sterilisation, should he suggest an apparatus worked by heat or one worked by filtration? In regard to the question of filtration in field service the amount of practical experience available was not large, and he would sooner be guided by the experience of Professor Notter than he would by his own. But he saw no theoretical reason why an efficient method of cold sterilisation by filtration could not be pro-

vided by existing means, and it was his personal belief that it could. He was perfectly ready to admit that so far as field service is concerned, where the filter had to be carted about, a single filter used for several hundred men, and there were difficulties of transport, filtration is not an easy matter. On the other hand, he was quite certain that sterilisation by heat on any substantial scale was, from a mechanical point of view—he would not discuss the bacteriological question—also not an easy matter. Practically one might call the apparatus mentioned by any name one chose, but they were the same thing—steam boilers with regenerative chambers attached. Professor Notter had alluded to this as a recent invention, but as a matter of fact the general arrangements dated back a good many years, ten years Dr. Rideal told him. The first real application of the principle of which he was aware was that of the late Charles Herscher, who certainly did as much as most men on the question of public disinfection. He had before him a diagram of the apparatus that gentleman used; it consists of a heater in which there are the annular chambers, the water circulating through them and going through concentric spiral tubes; the hot water goes out and meets the incoming current of cold water; the whole thing worked out on the regenerative principle. He had no hesitation in admitting that he had had occasion to consider how far that apparatus would be adaptable for the purposes of a field expedition, and how far he should be justified in asking the authorities to consider this as one of the practicable alternatives. Acting in some measure on independent expert advice, with which his own opinion concurred, he came to the conclusion that to send a man out with a piece of machinery involving a steam boiler and certain other things into the desert where the materials for repairs were not available, where if a tube burnt out it could not be replaced, where those mechanical difficulties which would crop up where there was steam under pressure could not be readily dealt with on the spot, and the future of the water and the health of the troops might be compromised in consequence, was a step not to be taken until every other means had been exhausted. On that ground he did not feel justified in asking the authorities who might be interested to consider this system for the regenerative sterilisation of water. The apparatus they saw that evening appeared to be an elegant adaptation of that particular principle. He had no doubt that within the limits of strength and lightness—and the margin of strength in the case of rough transit was large—it would be an alternative well deserving of consideration. But one point must not be overlooked: where they had a current of sterilised water passing through a number of continuous partitions separating it from the unsterilised water, it was necessary to have something very substantial in the nature of a joint. Little more was suggested in this than a cement joint, but an apparatus with fifteen feet of cement joint was liable to risk at some point; a leak would put the sterilised and unsterilised water into communication, and although he admitted the flat surface gave a larger cooling surface than one with spiral tubes, he thought it was a question to be considered whether spiral tubes would not be in

the long run more satisfactory as giving a sounder joint. He merely mentioned this point as a consideration to be borne in mind in regard to the possibility of sterilising by heat for field service, but in considering the application to institutions with a large supply he had much less doubt. It would require very exceptional circumstances to induce one to recommend the sterilisation by heat on a large scale rather than sterilisation by cold if it can be conveniently arranged. Installations of hundreds of thousands of gallons had been erected for cold sterilisation, and he saw no reason why there should be any limit to the amount. In particular, the introduction of plant working with vacuum instead of pressure had enabled unlimited quantities to be obtained without the increase of weight which was inevitable in a pressure system. These remarks were, as he hoped one's remarks on such matters always would be, applicable to no one system or apparatus. It must be taken as applicable both to any system of cold filtration which satisfied the bacterial and practical conditions, and to any system of regenerative sterilisation which was open to the criticisms he had made. Other things equal, one would naturally prefer a process which does not require heat, and judging from his experience of the last three years and the accumulation of his experience generally, especially in this country, he did not think there was ground for questioning the practicability of purifying water on whatever scale by means of cold sterilisation. That sedulous attention to which reference had been made was only required in installations where it was attempted to get more water through the tubes than the quality of the water allowed. He thought, in conclusion, that they would find that cold sterilisation will continue to be the favourite and best accredited method of purifying water.

Dr. S. RIDEAL (London) observed that the subject was one upon which he did not feel qualified to speak, because he had had no experience of barracks nor of prisons. He supposed that on the whole in prisons the amount of water drunk per head of the population would be greater than in barracks, and it would be interesting to ascertain the statistics in regard to institutions of that character compared with the quantity used for drinking purposes in municipalities and towns. With regard to filters, animal charcoal was very much maligned and was looked upon as a thing of the past. But Professor Notter in his criticisms of the disadvantages of animal charcoal mentioned a fact apt to be forgotten, viz., that substances like albumen will pass through a charcoal filter without being in any way acted upon, whereas the products of the putrefaction of such albumen—ptomaines, poisonous bodies, enzymes—are oxidized by such animal charcoal. Unsatisfactory as it was in some respects, animal charcoal was in other respects a very desirable filter, inasmuch as it oxidises the ptomaines or poisonous substances which may be present in the water. Such advantages could not be claimed for spongy iron; in fact, it increased the ammonia. The author's description of Mr. Rogers Field's sand filter was most interesting, for they were told that it had been worked a number of years and

practically yielded a sterile filtrate. That was a filter which should be a model filter for every water company in London to imitate.

PROFESSOR NOTTER: Of course the sand has been changed several times.

DR. RIDEAL said this showed that sand filtration was possible, and, as it gave remarkably good results it was a pity that sand filtration as a rule did not give such good results as Mr. Field succeeded in obtaining from this particular sand filter. He was not quite certain whether he agreed with Professor Notter in regard to the duplicate supply. Under certain circumstances a duplicate supply was desirable. In large towns where one could have a supply of sterile water for drinking purposes, it seemed a waste of money and time to sterilise the water used for flushing closets and sewers, or in case of fire. In dealing with barracks or prisons it was, however, quite possible to sterilise the whole water supply of such a small community; but in dealing with large towns he fancied a duplicate supply was well within health considerations at the present time. He agreed as to the undesirability of having several filters in different parts of a building; it was certainly the proper thing to have the whole system in one place, either as a battery of filters, or, if possible, sand filtration of the quality obtained by Mr. Rogers Field, so that the whole supply would be under one control and managed by one official. If he were advising for barracks or prisons he should say put in a supply of bacterial filters. There had been a question of the different values of the bacterial filters on the market, but it was hardly necessary for him to go into the differences of the Pasteur-Chamberland and other filters of that class. Recently they had had a long report of Drs. Woodhead and Cartwright Wood on this subject for and against both the Pasteur and the Berkefeld filter, but personally he was inclined to favour the Pasteur-Chamberland filter, as the friability of the Berkefeld filter and the difficulty of cleaning it, militates very considerably against its use in practice on a large scale. Professor Notter had given them a great deal of information about the use of chemicals. The idea of using bromine for the sterilisation of water was by no means new. Thus Dr. Franck in 1883 used *Kieselguhr* impregnated with liquid bromine, and Fischer and Proskauer in their experiments also used siliceous earth. In 1886 Bromidine, a mixture of bromide, bromate and acid sulphate was suggested, as it liberated bromine when added to water; and in 1897 a patent was applied for (No. 8094) for making tabloids of such a mixture which could be added to the water before use. (See also Rideal, *Disinfectants*, pp. 72, 73; Altmann, P. 5793 of 1897; Schumberg, Ph. C., 38, 239; and *Deutsch. Med. Wochenschr.*, 1897, 407). Sodium sulphite and sodium hyposulphite had also been suggested as "antibroms." The objection to such a system was the consumption of a certain amount of bromine, which he thought would not be recommended by medical men. There were disadvantages about the use of bromine for sterilising water which did



not attend calcium hypochlorite, but it was only a modification of the old idea of using chlorine or bleaching powder for effecting the same purpose. Large quantities of bromine had to be added, for it was absorbed by the organic matter present in the water; this was apparently not the case with chlorine, a small quantity of which would reduce the number of organisms in the water very considerably, .004 grs. of chlorine per litre was effective in reducing the number of organisms in sewage, and that was a very different matter to the .06 grs. mentioned by Professor Notter. Very remarkable and interesting results had been obtained in recent years by Prof. Délépine and others in the germicidal action of chlorine. Potassium permanganate was another substance which seemed to be working wonderfully in India as a germicide. Dr. Hankin was reported to have used it successfully for dealing with cholera and the plague, and it might also be useful in the field for the prevention of enteric fever, especially as the typhoid organism is an organism which is very easily killed, although as a germicide permanganate had a low value. With regard to sterilisation by heat, Mr. Wolff Defries had mentioned that the regenerative principle was not new. The objection was that it is expensive, but it was to be remembered that if they could only for an instant bring an organism to the particular temperature at which its vital agency ceases, then no consumption of heat theoretically is required. It was therefore a question as to whether it was possible to ensure all the water passing through such a steriliser being raised to the necessary temperature, and then cooled down to the original temperature of the incoming water. He congratulated Prof. Notter on the valuable résumé of the subject which he had given.

Dr. C. CHILDS (London) said that Professor Notter had treated the subject in such an interesting manner that he was glad to add his thanks for the excellent paper they had heard. Paradoxical as it might seem, he wished to protest against the filtration of water entirely; for he cherished the hope that they would live to see the time when the filtration or boiling of water would be absolutely unnecessary. What he earnestly advocated was the protection of all our water supplies and the prevention of pollution. He was glad to hear the remarks of the Rev. Mr. Lawrence who opened the discussion, for above all things they required to stir up the people of this country and to insist that the water which we used should not be polluted with human excrement. He understood that in France there had been a very considerable reduction in the amount of typhoid fever in the Army since the introduction of the Pasteur-Chamberland filter, and he would be glad to know if any similar observations had been made in this country. The great objection to filtration was that however skilfully it might be done it could not be regarded as in any way perfect. They had had reports of the two classes of filters mentioned, and the defect seemed to be that of allowing micro-organisms sooner or later to pass through; the imperfection in these perfected filters seemed in fact to depend upon the human element—



the difficulty of keeping them clean. He should be glad to know whether any one could really say how these filters could be so cleaned that they might always be depended upon in ordinary life for yielding practically sterilised water. He would be glad if Professor Notter could give them an idea of what recommendations they had in the Army for cleansing these filters, whether they were content with a mere mechanical cleansing or whether they submitted the filters to boiling. For laboratory purposes they were accustomed to sterilise them in the Autoclave, or in Koch's steriliser. By boiling these filters sufficiently they could at any rate destroy any bacteria which might have passed into the pores. How often these filters should be cleansed was another pertinent question. Some bacteriologists would cleanse them once a week at least: whereas one eminent authority would allow the slime to accumulate on the exterior, and rely upon that slime for efficient filtration. He did not know whether the authorities were agreed on this point and gave instructions how often domestic filters were to be cleansed. How far could they rely on such instructions being carried out in ordinary life? With regard to bromine, he would not like to undertake to answer Dr. Rideal's question as to its injurious effect without knowing the definite quantity of bromine Professor Notter advocated for sterilising ordinary water. As far as he understood a very minute quantity of bromine was required for sterilising water more polluted than an ordinary sewage effluent, and he would not be called on to use so much for ordinary water. What was the quantity used for ordinary domestic water, and for water used in the course of a campaign when water had to be taken from rivers, &c.? The quantity seemed to him not sufficient to be worth taking into consideration as far as any therapeutical or anti-therapeutical effect is concerned. Dr. Rideal had suggested that ptomaines would pass through the filters unoxidised, but the quantity of these ptomaines would be so very small that they could not harm any human being; on the other hand a number of microbes, say the *Bacilli Typhosi*, which might pass through a charcoal filter would do infinitely more damage than a small amount of ptomaines formed by other micro-organisms.

Dr. RIDEAL (London) explained that he was not advocating the use of animal charcoal filters. What he did say was that water should be well oxidized before it went into the bacterial filters, then the ptomaines were oxidized.

The CHAIRMAN (Dr. Louis C. Parkes) in closing the discussion, said that with regard to bromine, he preferred that no chemical substance should be added to water with a view to sterilise it: if the water was not sufficiently pure to drink then it ought to be made pure by some other way than the addition of chemicals. The continual taking of small quantities of bromine or other substances added to water might in time have a considerable adverse influence on the health of water consumers. With regard to the heat sterilisation

apparatus they had been considering, he thought that there might be a future before it for certain purposes, but it ought to be very carefully considered from the point of view mentioned by Mr. Wolff Defries, namely the connections of pipes in the interior of the apparatus. It was quite evident that an apparatus which had such a great number of joints must be constructed in the first instance with very great care, and ought to be periodically examined to see that nothing went wrong inside, otherwise there might be established channels of communication between the sterilised and non-sterilised water. In concluding, he asked the company to accord Professor Notter a hearty vote of thanks for his interesting paper.

The vote of thanks having been passed with acclamation,

Professor NOTTER, in acknowledgment, thanked those present for the kind way in which they had received his paper. In answer to the question as to the exact amount of bromine he proposed to use, it was  $\cdot 06$  gramme to a litre of water. The amount he had previously mentioned was for the worst sewage effluent he could get, and he did not intend to use the same quantity for drinking water. For bad water  $\cdot 06$  gramme would be quite enough.