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Some Problems of Water Supply for Troops

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SOME PROBLEMS OF WATER SUPPLY FOR TROOPS.

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The problems of water supply under field conditions are very different from those of the average city or town, even though the same fundamental principles apply to both. The city or town will in all probability make an extensive and careful survey of all water supply prospects and then choose that source which seems likely to offer the cheapest means of getting enough water that will be safe to use for drinking and other domestic purposes. Once the source is decided upon, expensive pumping and purification plants are erected and a complex distribution system is installed. A high degree of physical attractiveness is required in addition to the bacterial safety of the water so that the plant must be kept operating at a high degree of efficiency. This, of course, requires a trained staff of operators.

In the field, however, the opportunities for discriminating selection of water supplies and the development of water systems cannot be expected as a rule. Moreover the quantity of water which is available in a district may be entirely insufficient. This lack of water makes necessary the fullest use of existing supplies and in some cases necessitates the use of tank trains or ships or long pipe lines. The allied forces in the Gallipoli campaign were obliged to depend to a great extent on water which was brought to Anzac from Alexandria and Port Said in tank ships.

Operations in any particular territory bring about a great concentration of men in the district. This means that the quantity of water required will probably exceed that provided for in peace time by the inhabitants. It also means much greater amounts of soil pollution as well as contamination by seepage from latrines, burial pits and wastes in general. That is to say, there will be increased possibilities for contamination of water supplies and greater needs for the water.

In the present war it appears that actual poisoning of wells has occurred in addition to intentional defilement of wells and springs by means of manure, dead bodies and the excrements of the troops of the enemy. The use of chemical poisons—arsenical animal dips, extracts of poisonous mushrooms and probably other substances—are rather difficult to take out of water, but would probably best be removed by dilution on continued pumping of the well. The intentional or accidental defilement by body wastes and decomposing organic matter is serious on account of the possibilities of infection of the water by the specific organisms of such diseases as cholera, the typhoid fevers and the dysenteries. Advancing troops are likely to be visited with such of these diseases as have affected the retiring enemy. After the battle of the Marne, for example, the French suffered from paratyphoid fever believed to have been disseminated by carriers of the disease among the German troops.

It should not be concluded that these water-borne diseases have troubled only the recent armies, for the effectiveness of the older ones has suffered, too. Sanitary arrangements during wars have probably always been very poor and for this reason the disease-caused mortality has usually been much greater than that due to battle. The intestinal diseases have ranked high among army diseases. I do not mean to convey the idea that the cases of intestinal diseases are all water-borne because contact, flies, food and the general unclean surroundings also are contributory. However, the diseases are so serious in their results and so fatal to the effectiveness of an army that all available preventive measures should be employed.

In the present war the disease ratio is said to have been much reduced. It certainly should be, in the light of increased sanitary knowledge and the prophylactic or preventive measures applied. Among these preventive measures the inspection of drinking waters and their purification have high rank.

In order to know whether a water is poisoned or not, or whether or not it has been contaminated, inspections, sanitary surveys and analyses are made. Inspections of well casings may be made by lowering lights or by throwing a beam of light from a hand mirror into the well. Such inspections can detect the points where surface water is entering and may reveal the presence of bodies or other foreign objects if the well is pumped out. These objects may be removed by grappling or by descending into the well. The point of entrance of the surface drainage may be repaired to exclude the contaminated water. Before beginning the descent into any well, a candle should be lowered to see whether or not there is enough carbon dioxide in the well to cause suffocation. Wells which have been defiled are cleaned, pumped out repeatedly and treated with a heavy dose of chloride of lime or potassium permanganate. They are not used as sources of drinking water in the presence of sufficient pure supplies.

In many cases a sanitary survey of the surroundings of the source of water is valuable in locating the contaminating influences. Once located, steps to abate the nuisance may be taken.

Sanitary analyses and the more complete bacteriological examinations are usually limited to completely equipped laboratories. The motor field laboratories in use by the British armies and their allies are capable of handling this work. In addition to these, smaller and more portable laboratories have been designed. Some of these small laboratory outfits have a very limited field of usefulness. The smaller equipment can, however, be used with small bodies of troops or when the more cumbersome nature of the motor laboratory would interfere with the hurrying up of additional combatant units. Under the press of such conditions the examinations would in all probability have to be dispensed with and all drinking water presumed to be unsafe. The French had provided more than two hundred portable toxicological laboratories as early as the middle of 1915. These laboratories are particularly charged with determining whether or not wells have been poisoned by mineral poisons, alkaloids, glucosides, cyanides and the like. They are also expected to investigate the character of the gasses used by the enemy and to devise emergency defensive measures.

The Medical Department in our army is also charged with making such boiler analyses as are required for the military railways operated by the Engineers.

The use of the unstable hypochlorites of calcium and sodium in purifying water necessitates frequent analysis of the chemical employed in order to be sure that a sufficient quantity of the active chlorine is applied. Sometimes the water which has been treated by the hypochlorites is tested by means of potassium iodide and starch. In the presence of any free chlorine the familiar blue color of iodide of starch appears. A compound of zinc iodide and starch claimed to be very stable is also issued at times.

In the absence of data regarding the quality of water supplies as has been mentioned, all the water used is to be considered contaminated. When the quality of several sources is known, the water from the least polluted should be used, even though it is necessary to purify it by some artificial means. None of the processes commonly employed—excepting of course distillation—is able to remove such poisonous mineral substances as arsenic and the like. All are aimed at freeing the water from dangerous bacteria. Poisoning by mineral poisons can only affect the man who actually drinks the water, but a case of typhoid fever or cholera derived from a water may be communicated to a large number of others who are susceptible.

In order to reduce the necessary purification to a minimum the existing water supplies must be protected from further pollution. The curbing of wells may be repaired or built up so that water thrown near the well runs away at once. Good native wells are placarded and put under guard to prevent nuisances in their immediate neighborhood.

Where the supply is to be taken from a stream, the senior officer is required to designate the point at which the drinking and cooking water is to be taken. Down stream from that point places are selected for the bathing of men and animals as well as the usual fording back and forth. Considerable pollution of a stream may sometimes occur as a result of the necessity for crossing a river before selecting the source of the supply. Once the source is designated it is protected in the usual manner by means of notices and guards.

While good use may frequently be made of the better sort of native wells, the troops will sometimes be faced by the necessity of constructing new ones. Circumstances will dictate whether it is better to construct dug wells, or driven, drilled or bored ones. Driven wells are rapidly put down where the rock is not too hard and do not usually require a great amount of apparatus. On the other hand, they do not offer much opportunity for the storage of water. The British army has made use of a variety of the driven well which they called the Norton tube well. It was intended to be used by marching troops and for this purpose it was not a success, due chiefly to the amount of time required. It was adapted to loose mantle rock to a depth of only twenty-five feet. It took some time to get the water clear and it was often high in bacteria due to the contamination introduced in driving, for most new wells require some time to get rid of the bacteria introduced in putting them down. As a means of increasing a supply, however, the Norton tube well would have some use where the troops were expected to remain for a time in camp.

The actual purification of the water in the field is usually carried out in one of three ways: by heat, by filtration or by chemical disinfection. To be satisfactory the process used should comply with the following requirements: (1) it should be efficient under field conditions with the sorts of waters which the troops will encounter, (2) the apparatus and supplies should be light enough to be readily transportable, preferably without the aid of wheeled transportation, (3) the rough treatment likely to be received in the field should not throw the apparatus out of adjustment or render it unsuitable, and (4) skilled attendance should not be necessary to insure proper purification since the operator may be incapacitated in service.

There is no doubt that boiling offers the best means of rendering a polluted water safe. If the water is boiled for a few minutes nearly all bacteria are killed. A very small amount of apparatus and material is required. In some cases, however, the fuel is scarce or must be carried. The great disadvantages of the method, however, are the amount of time consumed in heating up the water and cooling it, and the flat taste which the water has unless re-aerated. In winter there is no trouble in cooling the water, of course, and the cooling may be hastened at other times by using porous jars, canvas bags or boilers wrapped in burlap. The outer surfaces are moistened and the evaporation of the water from the surface removes heat from the vessel. In practice the cooling is usually done over night. The vessels in which the cooled water is stored should be protected from dust and the men should never be allowed to dip their water bottles into the water. Any infection of the water will be followed by rapid bacterial growth since food conditions and the lack of opposition favor rapid multiplication of bacteria.

The heat-exchange sterilizer is an apparatus which has been designed to do away with the time lost in heating and cooling water in boilers of the ordinary sort. The apparatus is arranged so that the cold impure water is used to cool the hot purified water and at the same time effect a saving in heat. In order to have the apparatus efficient and yet deliver the treated water at a temperature near that of the raw water, the heat exchange surfaces must be as large as possible. This is accomplished by bending a dividing wall into a sort of accordion pleating or having the hot water pass through narrow tubes surrounded by the cold, impure water. An apparatus of this sort is efficient

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and can deliver purified water at a temperature only about five degrees above that of the raw water. The disadvantages are the necessity for skilled attendance, difficulties with sticking valves and the liming of the kettle and heat exchange surfaces as well as occasional difficulty in securing fuel. The Forbes sterilizer, which is of this type, was adopted by the United States Army in 1898, but has been abandoned on account of the troubles in the field. Wheeled mountings for these sterilizers have been designed in addition to the smaller portable types. Among the foreign apparatus are the Griffith, Rietschel and Henneberg, and Vaillard-Desmaroux types.

Filters of all sorts have been designed for use in the field. Improvised barrel filters made of two barrels—one within the other and the space between them filled with sand—are mentioned by most writers on military hygiene. There are also filters of cloth, sponge and charcoal. At the other extreme are the exceedingly fine candle-filters such as the Berkefield, Pasteur and Chamberland filters which operate under pressure.

Of course the filter should be constructed according to the service expected of it. The cloth, sponge and coarse sand filters can only be expected to remove the larger animal and vegetable forms of life, and the coarser suspended matter. They will not take out the finer suspended matter and bacteria unless they are aided by coagulants. In filtering a water containing much suspended matter the candle filters soon clog. They are intended to remove such small objects as the bacteria.

In the museum of the Equipment Board at Rock Island there are a number of filter-canteens. In these some sort of a candle-filter is set into the neck of the canteen and expected to operate by suction applied by the mouth. If these filters yield water sufficiently rapidly to satisfy the soldier, they cannot be fine enough to retain the bacteria, and if tney yield the water too slowly, the soldier will surreptitiously remove the filter and drink the unfiltered water.

The candle-filter has been widely used in military posts and has given good service when properly handled. It is necessary to clean and sterilize the candles frequently, as bacteria begin to grow through them in a few days. The cleaning and sterilization of a hundred or more of these fragile candles is quite bothersome. There is, moreover, continual difficulty in keeping the candle housings tight under pressure. For these reasons the candle-filter is not considered satisfactory for field use. The British army had a water filter-cart in use at the beginning of the war. It was a 110 gallon cart provided with a Pasteur filter preceded by a preliminary sponge filter. It was soon found that the filter candles were so fragile and unreliable that the carts were ordered used for the treatment of the water by chemical disinfection. The German army has experimented very extensively with all sizes of candle filters ranging from a single-candle knapsack filter to multiple-candle filters with a capacity of 2000 liters per hour.

Where coagulation is employed, a comparatively coarse filter may be used for bacterial removal. Chemical coagulation is dependent upon the production of a gelatinous precipitate in the water to be purified. This precipitate entangles the bacteria and suspended matter, thus gathering them into larger particles which may be more readily removed. Sometimes sedimentation alone is depended upon for the purification of the coagulated water and sometimes filtration is employed. The coagulant usually employed in military practice is alum.

Of the field filters using coagulation the most important are the Ishiji, Darnall, and drifting sand types. The Ishiji was the filter used by the Japanese in the Russo-Japanese war. The filter was a conical canvas baf with two radial arms or spouts a short distance above the bottom. In each of these arms there was a filter of charcoal and sponge.

The Darnall filter is the invention of Lieut. C. R. Darnall of the Medical Department. It consists of three nested galvanized cans in a crate, a siphon of iron pipe and a filter frame which attaches to the siphon. The filter frame carries a specially woven cotton-flannel filter cloth which is wrapped around the cylindrical metal frame when in use. A coagulant composed of equivalent amounts of potassium alum and sodium carbonate is supplied. In practice the apparatus is assembled and the filter sterilized by siphoning hot water through it. The chemical is then added (rate one pound to 550 gallons) and the siphon is started. The filter can deliver fifty gallons of water with a bacterial removal of 95 to 98 per cent. It weighs about fifty-two pounds when knocked down for shipment. Although the bacterial removal is sufficient to render safe a moderately polluted water, the filter should be depended upon only as a means of clarification. This is a very important office since chemical sterilization is more satisfactory with a well-clarified water.

The drifting sand filter is an adaptation of a devise perfected at Toronto. It has been put in use in the war zone chiefly through the efforts of Lt. Col. Nasmith, chief of the mobile laboratories of the Canadian army. The advantage of the apparatus is the continual cleaning and replacing of the soiled sand layer on the surface of the filter. It is larger, heavier and of greater capacity than the Darnall and Ishiji filters and therefore not so valuable for small bodies of moving troops.

The more important chemical disinfectants which have been used for field purification of water are the permanganates, the acid sulphates, iodine, bromine and chlorine. The latter is used in the form of the hypochlorites of calcium and the alkalies, as a liquid, or as a gas.

Ozone has also been employed, but it has the disadvantage of requiring considerable heavy apparatus including a gasoline engine and dynamo, as well as expert attendance. The same objection applies to the ultra violet ray apparatus which has been proposed.

Potassium permanganate is a slow and uncertain germicide. However, it will produce a brownish precipitate which may be used to advantage as a coagulant. The chief use of the permanganates has been in India where they have been extensively used in the disinfection of wells at times of cholera epidemics.

The acid sulphates—usually represented by sodium bisulphate—are dependent on their acid character for their disinfecting power. They, too, are particularly effective against the cholera organism. As much as one gram per pint is employed. The unpleasant acid taste is obscured by compounding into the tablets lemon oil and saccharin. They are not suitable for continued use on account of the laxative character of the sodium sulphate formed. They were supplied to the New Zealand troops during the Boer war and have been used during the present war by the British cavalry. The acid attacks the metal of the canteen and some canteens may yield toxic metals to the water. Troops who are to use these sodium bisulphate tablets are supplied with aluminum water bottles.

Iodine and bromine are not usually used for purification because they are more expensive than the chlorine compounds. Their germicidal powers are about the same. Any excess of the chemical remaining after treatment must be removed by some other chemical such as sodium thiosulphate. Bromine was strongly advocated in Germany about 1897 but has fallen into disrepute on account of the difficulties of administration. The French recommend the use of iodine only when chlorine or the permanganates are not at hand.

The most important process at the present time, however, is the chlorine treatment and I shall therefore describe it much more fully than I have described the uses of the other chemicals.

Chlorine is used in American municipal water purification in one of two forms, calcium hypochlorite or liquid chlorine. For treatment of water in the field the alkaline hypochlorites and lately aromatic chloramines also are employed. The action with all of these is probably much the same, namely, an oxidation and a substitution of chlorine for the hydrogen of amido groups in the bacterial protoplasm.

The germicidal power of calcium hypochlorite—also called chloride of lime or bleaching powder—was known in the early fifties. Koch's work in 1881 showed the great germicidal power of the substance in a more practical way for he tried out its germicidal action on anthrax bacteria and their spores, using the thread method. From these results and those of Nissen (113), Traube (131) took his cue for the application of calcium hypochlorite to the purification of drinking water. Traube used a little less than four parts per million of the chemical, corresponding to a little more than one part per million of "free chlorine." He added about two parts per million of sodium thiosulphate to remove the excess of free chlorine. Later experimenters followed Traube and tried both the calcium and the alkaline hypochlorites in water purification. The success of the hypochlorite treatment at the Bubbly Creek filter plant in Chicago in 1908 (106) showed the utility of the chemical for municipal water works and almost immediately this method of treatment was adopted as a standard procedure all over the country. About 1911 liquid chlorine began to supplant the hypochlorite on account of the greater mechanical advantages of the former in its administration. Chlorination of drinking water is now depended upon by hundreds of cities as a final safeguard for their water supplies. In the treatment of the stored surface water or lake supplies of some great cities like New York (using five hundred fifty million gallons of water a day) and Chicago (pumping seven hundred million gallons) chlorination is the only means of purification applied.

Such then, is the history of chlorination as applied to municipal supplies. Cantonment supplies, (as has been mentioned before), take on many of the characteristics of city supplies. At least sixteen of our cantonments and large camps in the country are using liquid chlorine and are applying it in the manner used by municipal plants. For the smaller quantities of water special procedures are employed—though the principles of the action are the same.

The great difficulty in the chlorination by hypochlorites is the loss of strength due to the escape of the free chloride or its combination with other substances. This difficulty is increased in warm climates—a fact which has suggested to certain Indian army officers some methods of using the chlorine as a gas. Calcium hypochlorite is not completely soluble. The sludge left after making up the solution is bothersome and retains some of the active chlorine. To avoid as much as possible of the loss of chlorine from decomposition the chemical is usually packed in air-tight cans.

When an excess of chlorine is used, an objectionable taste and odor will result. Different waters contain various sorts of organic matter which absorb varying quantities of the reagent. Sometimes the chlorine may combine with these substances giving rise to compounds which themselves have odors and tastes similar to those developed in the presence of an excess of the chemical. For this reason, the mere taste of the chemical in the water is not always an indication that a sufficient quantity has been used. The employment of coagulants—or their use in larger amounts—by removing much of this organic matter (including the bacteria) will in many cases tend to reduce this difficulty and at the same time give better bacterial removal.

Inasmuch as it is essential for good results that there be a residue of free chlorine in the water after the absorption, the different waters will require different amounts of the hypochlorite. The usual quantity applied in ordinary water works practice is from one to two parts per million of the calcium hypochlorite by weight. This is equivalent to .3 to .6 parts per million of free chlorine. (Weight U. S. gallon 8.3 pounds, British Imperial gallon 10 pounds.) It is customary in field work to add a sufficient amount of the chemical to give the potassium iodide-starch test after half an hour. Sometimes this result is secured by making the test on the treated water and sometimes the use of an overwhelming quantity of chemicals is depended upon. The excess is then removed by sodium thiosulphate.

A point of practical importance that is seldom mentioned in this connection, is the influence of low temperature on the treatment of water. It is well known, of course, that chemical reactions usually proceed more slowly or with decreased intensity at a low temperature. The influence of this retarded action in the coagulation of water is very easily noticed. The flakes of coagulant can no longer be seen floating in the water, or as the water works operator says, you have "pin-point coagulation." In the chlorination of water the retarding of the reaction is not so readily seen. The odor and taste are the cause of more complaints in the winter time and although the water will give the test for free chlorine after half an hour, the bacterial removal is not always satisfactory. The difficulties in the winter appear, however, to be more troublesome when calcium hypochlorite is the germicide than when the liquid chlorine is used.

In applying the hypochlorite, it is very convenient to make up a small amount of a stock solution using a known weight of the chemical and a definite volume of water. The desired amount of this solution may then be measured into known volumes of the water to be treated and carefully mixed. The Thresh method (130) provides sealed quarter pound tins of calcium hypochlorite and half pound packages of sodium thiosulphate. One tin of the hypochlorite is mixed into a gallon of water and the package of sodium thiosulphate is dissolved in another gallon of water to form the antichlor. The hypochlorite is sufficient for 8,000 gallons of water, making one part of the chemical in 320,000 parts of water (since the British Imperial gallon weighs ten pounds). The free chlorine employed is therefore a little more than one part per million. After fifteen minutes a volume of the thiosulphate solution equal to that of the bleaching powder solution is added to destroy the excess chlorine. It might be of interest to note that while ordinary bleaching powder contains 25 to 37 per cent of its active ingredient—available chlorine, the Bayer Company, a German concern, at the opening of the war produced a similar compound containing 75 per cent available chlorine.

The French have been using Javel water or solutions of sodium hypochlorite containing about 85 to 90 grams of free chlorine per liter. More dilute solutions rapidly lose their strength, especially if left exposed to the air and light. Since there is some loss even in the more concentrated solution, this must be titrated from time to time to determine its exact strength. The volume of this solution which is to be used naturally depends upon the strength of the solution. The amount of free chlorine recommended for use in polluted waters is 0.8 parts per million. The sodium hypochlorite has the advantage of being a relatively clear solution. It is, however, much more bulky than the bleaching powder containing the same amount of free chlorine. In addition the container is likely to be broken with consequent damage to any goods with which the solution may come in contact.

The Rhein method (124) uses antiformin instead of Javel water. To every liter of water 2.1 c.c. of antiformin and 1.1 c.c of 25 per cent hydrochloric acid are added. (Antiformin is similar to Javel water but is usually strongly alkaline with caustic soda.) The acid sets free the chlorine and it may reach a concentration of 110 p.p.m. After five minutes a tablet containing 0.45 grams of sodium thiosulphate and 1.7 gms. of $NaHCO_3$ is added. Gothe (103) has shown a number of errors in this paper, but the most important fault to be found with the process is the necessity for making accurate measurements of powerful chemicals. The ordinary untrained man might easily make a mistake.

Tablets or capsules of calcium hypochlorite have been suggested by a number of writers. All of these are open to the objection that they lose chlorine and are not suitable for use after a few weeks on that account even when packed in tight vials of amber glass. The tablets have been made of the chemical alone or in combination with sodium carbonate, lactose and so on. The density of the tablets is objectionable—especially when composed of the hypochlorite alone—since they must be crushed or else a considerable amount of the substance will be kept from taking part in the reaction. Vincent and Gaillard (134) claim that by mixing sodium chloride with the hypochlorite, crushing is made unnecessary. The salt dissolves out leaving the tablet so porous that all of the active chlorine escapes into the water within ten minutes. The tablet designed for one liter of water contains 3 to 3.5 milligrams of active chlorine. This will mean that the water will receive 3 to 3.5 parts per million of free chlorine.

Chloramine-T (sodium toluene sulphamide), one of the Dakin antiseptics, has been tried by Mackenzie Wallace in India. The antiseptic is very slightly soluble. Its action is very slow, although there is a marked retardation of the aftergrowth of the bacteria which usually results when the effect of the sterilizing agent has worn off or a re-infection of the sterile water has taken place. As much as .4 gm. of the disinfectant and ten hours' time are required for the sterilization of a liter of water. Another one of the chloramine group of antiseptics has been proposed by Dakin and Dunham (2) under the name of "Halazone," (para sulphon di chlor amino benzoic acid). This is said to be effective in a concentration of 1:300,000 with an interval of half an hour. The advantages claimed are less rapid loss of chlorine on storage and less rapid combination of the chlorine in use. It is supplied in tablets packed in amber glass bottles. The tablets have a chlorinous odor.

On account of the difficulty of securing and preserving calcium hypochlorite in a tropical climate, Treherne and Nelson (112) of the Indian army developed a chlorine gas method in 1912. The chemicals used are potassium chlorate and hydrochloric acid. The acid is in the concentrated form and the chlorate is in the form of five grain tablets. Two unbreakable bottles are supplied. The larger has a capacity of 24 ounces; the smaller of one ounce. Twenty ounces of water are put in the large bottle and three tablets of potassium chlorate are put into the small bottle with two drachms of the hydrochloric acid. The chlorine produced is bubbled through the water in the large bottle. When the reaction is finished, the contents of the small bottle are added to those of the large one. One ounce of the chlorine water added to 5 gallons of the water to be treated gives a dilution of 1:440,000. In half an hour the water is declared safe. With this apparatus weighing twelve pounds 9600 gallons of water can be sterilized without refilling. Rishworth, who has had experience with this method in the field, has suggested an apparatus similar to a siphon bottle for making the stock solution. Chlorine stored in small steel bulbs under pressure could be dissolved in the water.

The Lyster bag employed in the United States Army could be used for any of these methods of purification. It was devised by Major Wm. L. Lyster of the Medical Department. It is a bag of specially woven canvas 20 inches in diameter by 28 inches

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in depth. It is slung from a folding ring. Near the bottom are five self-closing faucets which are small enough to fit inside the neck of a canteen. It weighs about seven and a half pounds when empty and is intended to be carried by one of the men. When filled the weight is about 330 pounds. The chemical actually used is bleaching powder, which is put up in sealed glass tubes, containing fourteen or fifteen grains. A package (7½ inches x 3½ inches x 4¼ inches) containing sixty of the tubes weighs ten ounces. To treat a bag of water, one of these tubes is broken at the file mark it carries, and the contents mixed in a cup of water. The mixture is put into the bag which is then filled. In half an hour the water is ready for use. If the raw water is turbid, it is strained through a filter cloth or blanket. This of course will not remove fine turbidity. Comprehensive experiments have demonstrated that typical and dysentery bacteria, active amoebæ, ciliates and the like are killed within 15 minutes. According to Hurst (6) chlorination as usually practiced does not destroy encysted amoebæ.

SUMMARY.

1) Experience has shown that careful control of the drinking water supplied is essential to the health of the troops. The control measures include protection of existing supplies, development of new ones, inspection of all questionable sources and the purification of all contaminated or suspected supplies.

2) In the present conflict it is necessary to know whether or not a well has been deliberately poisoned as well as to know whether it is polluted with sewage-like material or decomposing animal matter.

3) The bacterial purification of water is best accomplished by heat or chemical disinfection, preceded, if necessary, by a preliminary clarification.

4) In spite of the possibility of unpleasant tastes and odors the chlorine compounds are the most satisfactory—as well as the cheapest means of treating water when heat is not practicable.

5) Bacterial multiplication in sterilized water is rapid in case of re-infection. Care should be taken to avoid dipping into the water with unclean vessels or allowing dust to blow into the container.

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