

symptoms described by Hunter. As the pain in the groin increased and fever appeared, he lay down. At 9 p. m. the temperature was 101 F. and the pulse was rapid. He declined medical assistance, feeling that it was unnecessary, but in one hour, i. e., 10 p. m., the temperature had risen one degree. At 10:30 p. m. he was given 100 c.c. of serum and the following morning another 100 c.c., and at 4:30 p. m. a third injection of 100 c.c. In spite of these injections a bubo appeared on the opposite side, showing the malignancy of the infection. After the third injection the temperature fell and on the morning of the third day became normal. On the fourth day two injections of 50 c.c. each were given as a prophylactic and the buboes rapidly declined in size and he made a good recovery.

While I was in Bombay the plague commission was engaged in successfully solving the question of the transmission of plague; preliminary communications have already appeared in print and further reports will soon be published. Their experiments prove that fleas from rats dead of plague are able to transmit plague to rats, guinea-pigs and monkeys.

By an ingenious method devised by Captain Liston infected fleas were secured by placing a live guinea-pig in a room in which plague had occurred. Although a rat flea will not by choice select another animal as its host, under the influence of hunger it will attack almost any living animal. A cage of healthy rats surrounded by a fine wire gauze, when placed in a room from which patients dead of plague had been removed, remained free from plague, whereas the majority of rats, exposed in a similar manner, unprotected by wire gauze, died of plague. When rats imported from England were thus exposed they all died of plague, which suggests that a certain proportion of Bombay rats are immuned to this disease. Complete protection of healthy rats, when confined in an ordinary wire cage and placed in an infected room, was secured by suspending the cage in the air or by placing it on the floor, provided it was surrounded by a strip of fly paper wider than a flea could jump. Infected fleas secured by the live guinea-pig method, when permitted to attack healthy rats, guinea-pigs or monkeys in flea-proof cages, caused an epidemic of plague among these animals. The discovery by Captain Liston of the rat flea on the body of a Hindoo dying of plague adds one more link to the chain of evidence tending to prove that the infected flea from the plague-stricken rat is the transmitter of plague from the rat to man. It will be most interesting to learn the precise manner in which this transmission occurs and the behavior of the *Bacillus pestis* while in the body of the flea.

For many years the natives of India have been convinced of the necessity, during epidemics of plague, of (1) evacuation of villages when disease and death appears among rats; (2) burning the houses of the villagers; (3) destroying the roofs of houses so as to permit the sunshine to penetrate all portions of the dwelling, as the flea prefers darkness. The correctness of this belief is easily comprehended in the light of the results secured by the plague commission, as is also the cause of the infrequency of plague among Europeans.

It is regrettable that the time allotted to this communication forbids a discussion of sanitary and quarantine questions, the present status of the treatment of plague by sera prepared in accordance with the methods of Prof. Lustig of Florence, Prof. Terni, formerly of Messina and now of Milan, and Dr. Brazil of San Paulo, Brazil. Consideration should have been given to the efficiency of adrenalin, spartin, caffein, the uselessness of alcohol and the undoubted value of Haffkine's serum as a prophylactic in plague.

THE QUALITY OF PUBLIC WATER SUPPLIES.*

WILLIAM S. JOHNSON.
Sanitary and Hydraulic Engineer.
BOSTON.

It is particularly gratifying to me to be called on to speak before a gathering of physicians, as it gives an excellent opportunity to air certain grievances which, as a sanitary engineer, I have against the physician.

One of the chief of these grievances is that there is often so little apparent relation between the quality of a water supply and the health of those habitually using the water. Engineering is supposed to be an exact science, and when the cause is present the engineer looks at once for the effect. It grieves him, therefore, when a water supply is obviously polluted, when it is known to contain excreta from typhoid fever patients, that the epidemic of typhoid fever does not follow. On the other hand, he is even more annoyed when, after he has introduced an unpolluted water supply, the high typhoid fever death rate which obtained when the polluted supply was in use is not materially reduced.

Another grievance of the sanitary engineer is the impossibility of obtaining from the physician any satisfactory conclusion as to the results of the use of water which is not contaminated by sewage but which has other features generally considered undesirable. For example, we have always wished to know the effect of habitually using a very hard water or a water containing large numbers of live or decaying organisms. We have been given vague answers to the effect that while no specific diseases may be caused by such conditions in the water supply, the general effect on the system is bad and may make the users of the water more susceptible to diseases of various kinds.

All this to the man of engineering training is exasperating. One or two well-known examples illustrative of our trials may be of interest. In the city of Lawrence, Mass., the water supply was for many years taken directly from the Merrimac River, and the death rate from typhoid fever in that city was abnormally high. In 1893 a slow sand filter was constructed through which all of the water supplied to the city has since been passed and the death rate from typhoid fever was immediately greatly reduced and has continued low since that time. This seems to be a clear case of reduction in the mortality from this disease due to the filtration of the public water supply. If this was the only fact which the statistics show, the results would be satisfactory, but coincident with this reduction in the death rate from typhoid fever is a corresponding reduction in the death rate from almost every other disease. In fact, the general death rate has been very greatly reduced since the introduction of filtered water. If we say that the typhoid fever death rate has been lowered by abandoning the polluted water supply shall we say also that the mortality from other than the so-called water-borne diseases is reduced by an improved water supply?

In the city of Washington, a polluted water supply has been in use for many years and the death rate from typhoid fever has always been high. Recently works for the purification of the water by slow sand filtration have been completed, but there has been practically no reduction in the number of deaths from typhoid fever.

Is it any wonder that the man whose training has

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been in an exact science is somewhat distressed by being met with such facts as these? Fortunately, however, the engineer, in dealing with water supply problems to-day, is working for something beyond the public health, namely, public comfort. The public, in many parts of the country at least, is no longer satisfied simply to know that the use of a water supply will not produce typhoid fever, but it is unwilling to drink water which is known to contain the excreta from human beings, or water which is so hard as to be unfit for domestic purposes, or water which is so highly colored or which contains organisms giving objectionable appearance, taste or odor. In fact, it is no longer satisfied with a water which is dirty, even though it may be safe.

It surprises us many times, when we carefully examine the sources of supply, to discover what we have been drinking and enjoying. It is not appetizing, to say the least, to think of drinking water from a pond which is frequented by fishermen. Neither is it appetizing to see cows wading in a stream which provides water for our table use, yet these are the conditions which we have contentedly endured until the more recent demands for clean as well as safe water.

Waters which are free from objectionable appearance, taste or odor, as well as free from contamination, are found in nature only in the ground. A good ground-water supply obtained from a spring or well is undoubtedly the most satisfactory supply which can be secured. A good ground water is clear, colorless, odorless and practically free from any organic matter whatsoever. Any community which is favored with large areas of sandy or gravelly soil from which water can be obtained has little excuse for having a poor water supply.

There are many cities and towns where water supplies of inferior quality are in use or where expensive filtration plants have been constructed, while there is an abundance of water of excellent quality in the ground which can readily be secured.

A point in favor of ground waters which may seem of minor importance but which really means much to the consumers is the low temperature at which the water is supplied to the consumer. The temperature of ground water as delivered in the houses during the warmest months has been found in Massachusetts to be from 52° to 55° F. The water derived from surface sources is delivered to the consumers at a temperature of from 70° to 75° in warm weather. The chief points to be guarded against in obtaining a ground-water supply are the presence of iron and an excess of hardness. Hardness is likely to occur when water is obtained from soils containing limestone. Iron occurs usually where there is much organic matter in the soil from which the water is derived or through which it passes on its way to the wells. The presence of iron renders the water almost useless for many domestic purposes, but it can be removed without any serious difficulty, although the iron occurs in many different forms and different treatment must be employed with different waters.

In speaking of water obtained from wells, I do not refer to artesian wells, but to shallow wells which have depths of from 30 to 50 feet. Artesian wells are undoubtedly of great value in many parts of the country, but in New England, at least, they are seldom satisfactory and can not compare with the shallow wells drawing water from sandy or gravelly strata at a not very great distance beneath the surface.

Where the area of sandy or gravelly soil is not extensive and the quantity of water to be obtained from

it limited, there are several ways of increasing the supply. If the water-bearing material is found in the vicinity of a pond or stream, the yield of the wells can be increased by infiltration from the neighboring surface-water source if the wells or filter galleries are properly placed. It is also possible to increase greatly the yield from the ground by flooding areas in the vicinity of the wells with water from some surface source. These are things which should be done intelligently, since trouble is apt to occur if surface water enters the wells too rapidly and is imperfectly purified.

Ground-water supplies have been in use for many years, but there are many places where the water-supply problem could be solved very satisfactorily if these sources of supply were better understood. It has been unfortunate that such supplies have been developed by well drivers rather than by engineers. The selection of a ground-water supply by a well driver is much the same as the regulation of plumbing by plumbers as practiced in many of our cities.

Where ground waters can not be obtained, the most satisfactory substitute to meet the modern demands for a water not only free from pollution but free from other objectionable characteristics is a filtered surface water, and the time is not far distant when all surface waters will be filtered before being delivered to the consumers. It is now possible to make almost any water suitable for domestic use by applying the proper treatment, but there is a tendency to think that because any water can be made suitable for domestic purposes any water will do as a source of supply, providing it is filtered. In fact, the advisability of neglecting the sources of supply and filtering the water is being publicly advocated in some places. This, it seems to me, is a very dangerous tendency.

Certain of the dangers attending the use of a polluted water supply after filtration are obvious. We need only recall the recent epidemic of typhoid fever in Butler, Pa., where a large percentage of the population was stricken with typhoid fever on account of the temporary shutting down of the filtration plant while making necessary repairs. Other examples of perhaps less serious character have occurred which show on how slender a thread the health of a community hangs which depends for its water supply on the proper operation of a filtration plant managed frequently by ignorant workmen.

There are some cases in which it is necessary to use water which has been polluted, and in such places the only safeguards are in properly designed works so constructed as to make it difficult to operate them improperly and in the operation of the works by competent and trustworthy men.

Surface water sources can be greatly improved in many cases without filtration. The most effective method is by storage for a considerable time in a deep pond or reservoir, with bottom and shores free from loam and mud or other organic matter. It water could be stored for a sufficient time and under proper conditions all disease germs would be killed, the water would become colorless and in every respect excellent for domestic purposes.

The water found in such lakes as Winnepesaukee in New Hampshire is at most times an almost perfect water, notwithstanding the fact that many of the tributary streams contribute water of very inferior quality. I say at most times, for all such waters are subject to objectionable tastes and odors. The conditions in Lake

Winnepesaukee can be approximated artificially and some of the reservoirs recently constructed, like the Wachusett reservoir of the Metropolitan water works in Massachusetts are giving water of most excellent quality, although the water entering them is highly colored and contains large quantities of organic matter.

The best evidence we can have of the safety in the use of such waters is the fact that our large cities, like Boston and New York, which are supplied from storage reservoirs, never have an epidemic of typhoid fever which can be attributed to the water supply, although the feeders of the reservoirs are known to be polluted. The weak points about such supplies are the possibilities of local contamination which may quickly reach the point from which water is drawn and the occasional troubles from tastes and odors due to growths of organisms.

Running streams are the least desirable sources of supply and I do not believe there is any stream, accessible for water supply purposes, which can be considered a safe source from which to take water directly. Although there may be no permanent sources of pollution on the watershed, it is absolutely impossible to prevent access to the stream, and when we consider that any pollution entering the stream at any time is almost immediately taken into the distributing pipes of the water supply system, the danger is obvious. Such supplies, if used at all, should invariably be filtered.

Experience is showing us that the nearer we get to nature, either in disposing of sewage or in obtaining a water supply, the better the results secured. The old-fashioned cesspool which has been so much abused is now considered the best method of disposing of small quantities of sewage. In methods of water purification the most satisfactory are those where nature is assisted as little as possible. The addition of chemicals or the construction of works which require constant personal attention, while frequently necessary, should be adopted only as a last resort.

FILTRATION OF PUBLIC WATER SUPPLIES.*

HARRY W. CLARK.

BOSTON.

The purification of municipal water supplies by filtration has been practiced for over seventy years. Apparently the first filter of considerable size was that constructed by the city of London in 1829, and that city now has about 120 acres of sand filter beds. Berlin, Germany, built water works and sand filters in 1856, fifty years ago, and at the present time practically all the important cities of Great Britain and Germany filter their water supply if this water is taken from a surface source. Filtration of public supplies is widely practiced in other countries, especially Belgium and Holland. Even Russia has several large municipal filters; a recent article in the *Engineering Record* describes large sand filtration plants in Japan, while in India and Egypt a number of large municipal supplies are treated by mechanical filters.

The first large municipal filter in America was constructed at Lawrence, Mass., in 1892-93, although at Poughkeepsie and Hudson, N. Y., St. Johnsbury, Vt., and Nantucket, Mass., small filters had been previously

built, the first one being that at Poughkeepsie, N. Y., constructed in 1872. During the last half of the last century public water supplies in America increased greatly in number, but perhaps the true beginning of the modern desire for pure water in this country, in distinction from the desire for enough water, was given by the State Board of Health of Massachusetts in 1886, when systematic examinations of the water supplies of the state were begun, frequent analyses of these supplies made and the Lawrence Experiment Station established.

Filtration of water is resorted to for various causes: To remove disease germs and render a polluted water safe, to remove undesirable organic or mineral matter present in suspension in water and thus improve its appearance, to remove color and to remove tastes and odors and the organisms causing these tastes and odors.

The first municipal filters were constructed for the purpose of improving the appearance of public supplies, and for many years the removal of organic and mineral matter in suspension in the water was believed to be the chief benefit of filtration. Studies showing the efficiency of sand filters in removing bacteria from water were begun in Berlin in 1884 and since that date the water supply of the city of Berlin has been systematically examined bacterially, and since 1888 constant bacterial examinations of the water supplies of London have been made. In 1887 the Massachusetts State Board of Health began at the Lawrence Experiment Station its investigations on the filtration of water and the purification of sewage, and since then notable studies of the science of water filtration have been made by various municipalities in this country. At Lawrence the studies for many years were directed entirely to what is known as slow sand filtration, but of late years other methods have been studied at Lawrence and mechanical and other forms of water filters have been operated. The improvement of water by double filtration has also been extensively studied there.

The municipal studies in America have been directed almost entirely to determining the comparative efficiency and applicability of sand and mechanical filters in the treatment of the various kinds of water necessary to use in various sections of the country, together with studies of sedimentation, coagulation by different coagulants, etc. In the Lawrence studies more than seventy-five experimental water filters have been kept in operation for periods varying from a few months to fourteen years, and with the laboratory facilities of the station almost every conceivable determination of the efficiency of these filters has been made. Daily determinations of the bacteria in the raw and filtered water and chemical analyses to show the work of the filters in removing color, organic matter, etc., have been made; the effect on filter efficiency of different rates of operation, different depths of filter and filter efficiency when treating different waters have all been exhaustively studied and the results given from year to year in the Lawrence Experiment Station reports.

Since the Lawrence filter was built in 1893 sand filters have been constructed at Mt. Vernon, Albany, Providence, Philadelphia, Washington, Yonkers, New Haven, Springfield, Bar Harbor and other places, and such filters are in process of construction at Pittsburg, Pa., Cincinnati, Ohio, and South Norwalk, Conn. Investigations are also under way looking to the filtration of the old and new water supplies of the city of New York.

Mechanical filters began to be extensively used in America, especially throughout the south and west, in

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