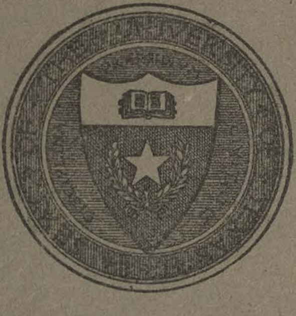
Publications Committee

University of Texas Bulletin

No. 1733: June 10, 1917

WATER SUPPLY AND SANITATION

Papers Presented during Municipal Engineers' Week at the University of Texas, February 13-15, 1917, under the Auspices of the Department of Engineering



Published by the University six times a month and entered as second-class matter at the postoffice at
AUSTIN, TEXAS

Publications of the University of Texas

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B128-817-1m

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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A paper on *Activated Sludge Sewage Disposal* was read by F. A. Wilson, of the San Marcos Utilities Company, but a copy of the paper was not available when this bulletin went to press.

A paper on *Street Lighting,* read by Professor J. M. Bryant, of the School of Electrical Engineering of the University of Texas, will appear later as a separate bulletin.

STREAM POLLUTION

STATE REQUIREMENTS AS TO SEWAGE DISPOSAL

By V. M. Ehlers, State Sanitary Engineer

[*Synopsis:* Why pollution of streams should be restricted; requirements of the law; method of procedure of a municipality under the Act; plans are not approved by the Board of Health, but the effluent is passed upon and must come up to certain standards; what determines standard of purity for any given case; necessity of sterilizing all effluents from disposal plants; results already attained.]

For the conservation of the public health, of our water supply; in order to protect our fish and oyster industry, our live stock industry; to promote truck farming and irrigation; to comply with the navigation laws; and for aesthetic reasons, state regulations as to sewage disposal are imperative.

According to one of our leading sanitarians, "No animal can live too closely to his bodily wastes, nor has he a right to pass them on to his neighbors." In this age of preparedness, Senator McNealus foresaw the eventuality that would transpire if a check were not placed upon stream pollution. Up to the present time, with only a small number of cities sewered, several streams had become so polluted as to become foul and a nuisance to the people living along the stream. Fish life was destroyed, and oyster beds were jeopardized. Typhoid epidemics were conclusively traced to stream pollution. A number of our towns depend upon streams for water supply. A few of them have water treatment plants, but, still, the raw water, without pollution restricted, may become too great a burden for the plant. Several truck gardeners were forced to abandon their plans, perhaps mainly due to public opinion, which arose against the polluting matter in the water used for irrigation. Complaints have been many from farmers relative to the pollution of their stock water. In order to make our rivers navigable, pollution must be restricted. From a public health standpoint, pollution must be restricted.

The intent of the commonly so-called "Stream Pollution Act" is to preserve the purity of our water supply. This includes all water courses or public bodies of water from which water is taken for the use of the farm, for livestock, drinking, and domestic purposes. Under its provisions, it is unlawful to discharge untreated sewage, factory and dairy waste, or to dump dead animals, garbage, night-soil, or any unclean, poisonous, or filthy matter, upon the watershed or into a water course or any public body of water, so as to impair the natural quality of the water. This Act is applicable to all persons, firms, corporations, municipal and county institutions, located within the corporate limits of cities and towns.

Cities and towns located on tide water are exempted, but cities and towns located on the Rio Grande, Canadian, Pecos, and Red Rivers come within the provisions of this Act. A violation of the provisions is punishable by a fine of not less than one hundred ($100) dollars nor more than one thousand ($1000) dollars. Upon the conviction of any person under the Act, it becomes the duty of the court to issue a writ of injunction enjoining such persons, corporations, or authorities responsible for such pollution from continuing the same. It becomes the duty of the State Board of Health to enforce the provisions of this Act. Mr. N. M. Baker, editor of the "Engineering News," and other Eastern engineers have interpreted the above as drastic. Conditions, however, are materially different between our state and the Eastern states, ours being an agricultural state, while the Eastern states are more adapted to manufacturing. Our riparian owners make use of the streams by taking water from them, while the Easterners, on the other hand, use the stream by discharging factory wastes and partially treated sewage therein.

Several towns are handicapped on account of their bonded indebtedness from meeting the requirements of the Act. No provisions are made for financing the construction of sewage disposal works. Plans submitted to the Board of Health, in accordance with their regulations, are examined and criticised. No plans are approved, but, if found meritorious, the following statement is given: "The plant, if constructed in accordance with the plans as submitted, and properly operated and maintained, will, in our opinion, render an effluent that will be satisfactory to this department." By this method of procedure, it is hoped that the various treatment work will be properly operated and maintained. Authorities will be held responsible for the character of the effluent coming from the plant under jurisdiction at all times. All conservative mayors and responsible engineers submit their plans. It is the freak and the promoter who avoid this feature, and, as a consequence, the community will bear the burden. It is, therefore, well to counsel with the State Board of Health before starting construction. But, in the opinion of the writer, the authority to reject plans should not rest within the hands of one man.

The Act became effective January 1, 1917, and since its passage an unprecedented record of sewage treatment works construction has followed. All plants constructed are not perfect; the department has not been able to comply with all the demands made upon it. We have found well designed plants carelessly constructed: in one case, the tanks were constructed of materials that leaked like a sieve; in another case, the plans submitted were only partially followed out.

For the guidance of designing engineers the following regulations have been prepared.

(1) That, for each river and waterway, at any given point, there shall be a minimum limit standard of purity, and this minimum limit is dependent upon the amount of sewage effluent discharged. The reasons for this limit are not the same in all cases, but vary according to the use that is made of the river, or the water of the river, and according to the character of the territory through which it flows. No universal standard of purity can be wisely established or maintained.

(2) That, while no universal standard of purity can be established, it is believed to be feasible to establish and maintain appropriate standards of a general nature for waters that fall within certain groupings.

(3) That sewage waste matter, before being discharged into

any river or waterway, shall be purified to such a degree as not to affect health in any way by a reasonable use of the river water; or to cause sensible offense to public decency; or to cause material injury to the fish or shellfish industry; or to cause the silting up of channels of navigable streams.

(4) That, even when the demands of public health, decency, and protection to the shellfish industry are such as to require a high standard of purity, the economic aspects of the case should be considered, the fundamental principle being that the results accomplished shall be reasonably commensurate with the cost of prevention of pollution.

(5) That, inasmuch as the safety of public water supplies is the most important element in the problem of stream pollution at the present time, the following general principles should govern the discharge of sewage effluent and waste matter into the rivers and waterways:

(a) Streams from which water supplies are taken without purification should not receive any sewage effluent or waste that will render the water a menace to health, or otherwise impair its natural quality.

(b) Streams from which water supplies are taken and used for purification should not receive a sewage effluent or waste of such character as to put an unreasonable burden upon the purification works at any waterworks plant.

(c) Streams not used for water supplies may receive sewage effluent of such character that its entrance will not sensibly offend decency in the reasonable public use of the stream, or cause interference with valuable fish industries.

(d) Harbors and tidal estuaries may receive sewage at such places and in such amounts that the discharge does not principally offend decency in the reasonable public use of the water, or cause interference with navigation or with valuable fish or shellfish industries.

Temporarily:

(1) Streams from which water supplies are taken (or may be taken in the future), below the point of discharge, may receive sewage effluent having a stability of 96, according to the methylene blue test, and a bacterial elimination of (this point

to be specified by the State Board of Health in each particular case). Apparatus for disinfection of the sewage effluent shall be provided.

From the above regulations, you can see that no drinking water standard is required, and that the board is in accordance with the engineers when it states that the results accomplished shall be reasonably commensurate with the cost of prevention of pollution. However, the board places a considerable value upon the prevention of pollution, and rightfully it has done so.

Frequently we hear the Act criticised for not placing the same restrictions on the rural districts as on incorporated cities. The farmer of today realizes the importance of properly disposing of his sewage. Much work has been done along this line in recent years by the State Board of Health and the International Health Commission. The Legislature, in its wisdom, has been most liberal in providing for rural health work, and we earnestly hope for the time when the unsanitary dry closet is a thing of the past in this state.

Barnyard drainage reaches streams during high stages, which, while not desirable, is not nearly so dangerous to public health as human wastes.

The results accomplished up to the present writing have been more than satisfactory. Much, however, is left undone; the study of our streams, their powers of self-purification, and experiments on different methods of sewage treatment are needed. The Act has also been an educational one, has been conducted upon a moral plane, met with the approval of welfare associations, and is today responsible for much of the activity along water purification, garbage incineration, and other lines of sanitation in this state.

City officials and engineers deserve much credit for what has been accomplished.

A DRY CLOSET SYSTEM

BY ED H. MCCUISTION, Mayor of Paris, Texas

[*Synopsis:* Type and size of pail and lids used; description of collecting wagon, dumping station, and arangement for cleaning buckets; system of card indexing used; use of liquid disinfectant recommended; pails collected during day in preference to night; cost and frequency of service; fly breeding.]

The courtesy of a place upon this program was not extended to me because of any special engineering skill or equipment for handling this subject, but rather because the city with which I have been intimately identified for more than ten years has inaugurated a pail system with which dry closets are equipped that has elicited favorable comment. In discharging the obligations imposed by this courtesy, I shall briefly describe the various features of the system to which reference has been made, and then emphasize such of them as may appear most practical and commendatory.

The pail used is made of 24-gauge galvanized iron throughout. At its mouth, its metal is turned over a 3/8-inch iron rim, and a bail of the same dimension iron is used with which to handle it. At the bottom of the pail the metal is crimped in such a way that a rim is formed which prevents the bottom from dragging or scouring on the floor when the pail is in use. The ears are firmly and securely riveted. The lid is slightly cone shaped, and the tongue of the lid slightly crimped, and fits closely into the pail, and all lids are interchangeable among the buckets. The wagon has low wheels and broad tires, should have the cut-under feature, and ours provides for the accommodation of sixty-six pails, on two decks, with three pails abreast. The dumping station, in its outside appearance and size, resembles an ordinary corrugated iron garage. It is floored with concrete, with a well in the center, to which drainage from every part of the structure points. The well is equipped with a man-hole cover, thereby enabling the service wagon, as it approaches with a load, to drive over it, where the stop is made, and the pails are unloaded on the concrete floor. Then the wagon is carefully washed with hose and water under pressure, whether soiled or not, all drainage going, by gravity to the concrete well, directly connected with the sanitary sewer system.

Immediately adjacent to the dumping station are drying racks and a vat in which all pails are carefully and thoroughly washed, then placed in the drying racks for air and sunshine, before again re-entering actual service.

Before work is begun, a sanitary survey of the entire city should be made, and a card prepared showing the streets, house number, and the number of persons served on the different premises by the proposed dry closet. These cards are filed in the office of the Sanitary Commissioner by streets, and one pail is provided for each five persons. When the service wagon is loaded with empty pails for a trip, a batch of cards corresponding to the exact number of pails on the wagon is given to the driver by the Sanitary Commissioner. These cards are arranged in the order in which the premises will be reached by the driver as he goes into the field. Each card discloses whether there is one or more pails on the particular premises. When the first premises are reached, if two pails are to be installed, the driver takes out the two pails that have been in service, removes the lids from the clean ones and places them upon the pails so removed, puts in the new ones, and returns to his wagon.

This, brief as it may appear, is a bare statement of the essentials of the pail system so successfully employed in Paris.

This plan of handling the dry closet was devised under the belief that it eliminated many of the obnoxious features common in all of the conventional methods in general use. In the first place, the size of the pails employed and their manner of installation reduce the expense of converting the average closet in general use to a mere minimum. The size of the pail is such that, when filled, a laborer can easily carry two without feeling himself overloaded, and place them on the wagon without inconvenience. Being comparatively small, they are more easily washed, more perfectly cleaned, and handled with greater facility at every step throughout the service circuit they make. The wagons used were built especially to fit the requisite number of pails, were double decked, and thereby thought to meet all the requirements most essential to general service. Experience, however, has demonstrated that a single deck would prove more practical, and that curtains, or tarpaulins of some kind, which would obscure the pails, would also prove beneficial. The new wagons which we now have under construction, embodying the above mentioned features, will, in our judgment, prove quite superior in many respects to the old ones in use. The advantages of a pail system over others in common use are many. In the first place, it avoids all soil pollution of every character. The use of a liquid disinfectant and deodorant in the pails when placed in service assists very materially in preventing fermentation, thereby reducing odors to the minimum, and also in keeping away flies during the summer; and, where the service is prompt and the regulations for use are observed, the system is very acceptable.

It is necessary that toilet paper be used. If newspaper, rags, cotton, or similar accessories be employed, the fly breeding will not be eliminated. The use of a liquid disinfectant in the pail, to begin with, furnishes a favorable field for the reception of all waste matter, and one into which flies and other insects cannot go. The use of toilet paper, which speedily liquefies, very effectually prevents any waste matter from remaining exposed above the surface of the germicidal fluid in the pail and becoming accessible to flies, which may scatter intestinal infections from it as well as breed in it. It is a well-known fact that, in the ordinary open closet, where the ground is the receptacle, soil pollution for a considerable distance around the closet is so general and so obnoxious that every such closet is a real menace in the community. If vaults are installed, or boxes, the waste matter deposited remains accessible to flies and other insect carriers. The expense of cleaning and the odor incident thereto are much more objectionable from every standpoint than in the case of the pail system.

Another feature of the pail system which has rendered it both more economical and more popular is that, with closefitting lids and pails as containers, the work may be done during the day, and the rapidity with which it is done is such that it is much more economical than the conventional methods. Previous to the installation of this system, Paris had an ordinance which required the open ground closet to be cleaned once a month, for which a charge of 75 cents was made. The work was not done by the city. The private owner of the system was driven either to work for those who paid him or to spend a good portion of his time collecting delinquent accounts. All closets which receive regular service paid $9.00 per year. Under the pail system, which succeeded the former method, two pails in a single closet were removed once every two weeks for the entire year for the sum of $4.00; or, if one pail only was used, $3.00 was the charge. No time is spent collecting delinquent accounts. All property owners are required to come to the office of the City Secretary and pay in advance, either by the year or even by the quarter, if they prefer.

It is the sincere belief of those who have most carefully observed the working of the present system that a material reduction in the number of flies which infest the city was noticed from the first summer it was installed. The observation was made in face of the fact that no systematic effort had been made to remove slop, stable waste, and other garbage debris from the residence districts of the city. The pails used cost 48 cents; the lids, 15 cents each; the wagons, as specially built, $85.00; the dumping station, probably $150.00; and a sewer service from the dumping station to a main outfall line of the sanitary sewer system, probably $250.00 more.

Briefly, this constitutes the equipment necessary to install a system of this character. It should be borne in mind, however, that there is a decided advance in galvanized iron, and that the pails would cost somewhat more than was originally paid. It should also be borne in mind by those who install this system that its chief cornerstone and indispensable requisite to its success is perfect cleanliness. Pails slovenly washed, wagons not carefully kept and left uncurtained, will prove very detrimental to the popularity and general acceptability of the system. The installation and operation of this system has elicited a large number of inquiries from all parts of the country. Those most frequently made are:

First: "Do you screen the closets or otherwise so construct them that flies cannot gain access to the pails?"

To this, we have answered that in the original installation of the system a few closets were so screened, by way of experiment; but we found that the hinged flaps soon warped, and that the opening and closing of these hindered the men to some extent in their work. We further found that, where toilet paper only was used, there was little, if any, attraction for flies, unless the contents of the pails had fermented, which sometimes happened during the summer months. Where fermentation did occur, the mere presence of the flies was the only objectionable feature: they could not gain access to the excreted matter, because it was immersed. Of course, if newspaper, cobs, etc., were used, the presence of these in the pail gave the flies their opportunity to become contaminated and thus spread infection. The very simplicity of this system, as well as the small cost which attends the adaptation of the conventional closet to its use, is one of the features which so strongly commends it for universal adoption. Many of the closet systems now so frequently recommended involve an expenditure in the construction of a closet that is but little less than the amount necessary to make a sewer connection.

Another inquiry often received is: "Who pays the sanitary fee?" Our ordinance provides that the owner of the property is held responsible in all cases except where such owner is a minor, a non-resident, or for any other reason is beyond the jurisdiction of the Recorder's Court. In such cases, the tenant may pay the fee in the name of the owner. We also have another provision in the ordinance making it a misdemeanor for a tenant to occupy premises and use a dry closet upon which the fee has not been paid in advance. All such charges are required by ordinance to be paid in advance, and those not paid by the tenth day after the beginning of the quarter become delinquent, and such delinquency is defined as a misdemeanor and punishable by a fine which, together with the cost, is much more than the bill. It is needless to say that, thus far, we have not found it necessary to impose but a single fine. A few arrests have been made, but the court has, after hearing the excuses, felt constrained to dismiss the cases, except in the single instance above referred to. We have sustained some losses, but these are traceable to carelessness in our clerical department, sometimes in not making a bill properly, and, in other instances, in not turning the matter over to the police department.

It is my conviction, after a careful study of a considerable number of dry closet systems, that the one we supply is, when all features are fully considered, decidedly one of the most practical and workable. Its easy, inexpensive adaptability to all communities where the conventional closet is in use, it seems to me, is one of its strongest claims to public favor.

It should be remembered constantly that this system is not intended to supplant or to retard the connection of premises with the sanitary sewer system. No system of which I have any knowledge can, in any legitimate sense, be said to justify this. All dry closet systems are makeshifts, and should be so regarded.

BACTERIOLOGY AND SANITATION

BY I. M. LEWIS, Associate Professor of Botany, University of Texas

[*Synopsis:* Parasitic and non-parasitic bacteria; effect of environment upon growth of pathogenic bacteria; five avenues through which bacteria may be thrown off by a diseased individual; routes of transmission and portals of entry to the system; water and milk as routes of transmission of disease; advantages and disadvantages of pasteurization.]

Bacteriology, the newest of the natural sciences, is altogether modern. Although bacteria were first discovered more than two hundred years ago, their importance in nature was not clearly understood until very recent times, and new additions to our knowledge of them are being made almost every day.

Bacteria are very minute vegetable organisms which, like all other plants and animals, consume food, grow, reproduce themselves, and are influenced in their life processes by their environment. They are widely distributed in nature, being present in great numbers in the soil, in water, in milk, in foods, in the air, as well as in and upon the bodies of plants and animals.

Bacteria may be roughly divided into two great groups, on the basis of whether they are parasitic or non-parasitic for man. The non-parasites are very much more abundant than the parasites, and their life habits are quite different. They are the organisms that are concerned with the work of decomposing organic substance. They make possible the existence of all other forms of life, for, if it were not for decomposition, the elements necessary to sustain life would soon become locked up in compounds and could not be released. The work of these organisms is of great importance from the standpoint of sanitation.

Parasitic bacteria bear a close relationship to the animal on which they live, and are usually highly specialized as regards their life habits. Such organisms have become accustomed to growing at the temperature of the animal body, and to using only certain foods; and they are, as a rule, unable to adapt themselves to other conditions. They are at home only while in the animal body, where they grow, multiply, and produce the chemical poisons which cause disease.

A knowledge of the behavior of pathogenic bacteria after they are expelled from the body is of supreme importance to students of sanitary science. It was long believed that these pathogenic forms, after leaving the body, continued to grow and multiply and lead a saphophytic existence, much as the non-pathogenic forms do. This has, however, been found to be erroneous, except in a few special cases. The great majority of organisms capable of causing disease are not at home in the lifeless environment outside the animal body, and are not only unable to grow and multiply, but can survive for only a limited time in external nature. Some of them are able to resist such conditions much longer than others, and upon a knowledge of this fact certain sanitary measures are based. The bacillus of influenza and the gonococcus, for example, die very quickly; while the tubercle bacillus and the typhoid bacillus are much more resistant, and have been known to survive for months. The anthrax spores may live on the wool of sheep for several years, and then prove capable of transmitting this disease.

There are a few special cases in which organisms capable of causing disease are known to grow and multiply in the soil. The best known example of this is the anaerobic bacillus responsible for tetanus. This organism is a normal inhabitant of the intestines of the horse and sheep. The spores are capable of great resistance, and multiplication takes place after the same manner as other soil bacteria. Such cases are, however, the exception, and not the rule.

It follows, then, that infection in most cases depends upon contact, either directly or indirectly, with material recently cast off from the body of a diseased individual. We may conveniently consider the subject of sanitation by noting the avenues through which organisms are discharged from the body, the routes of transmission, and the portals of entry to the body. These points will be found to vary somewhat in different diseases.

There are five chief avenues through which bacteria are thrown off from the body of a diseased individual. They are: the feces, the urine, the blood, the sputum, and the skin. Diseases may be grouped into classes more or less accurately on the basis of the avenue by which the causal organism leaves the body. It is obvious that intestinal diseases leave the body principally through the feces, that eruptive diseases are thrown off from the skin, while diseases of the mouth and throat are carried away by the sputum. It can not be over emphasized that these substances are the original primary bearers of diseases.

The chief routes of transmission are water, air, insects, milk and other foods, and contact or droplets. It is customary to speak of diseases as water borne, air borne, insect borne, milk borne, or contagious.

The portals of entry to the body are: the alimentary tract, the respiratory tract, the genito-urinal tract, and the skin through wounds or bites of insects. It is obvious that the chief duties and responsibilities of the sanitary engineer are to erect efficient barriers to these routes of infection. This is by no means a small task, and his success depends in a great measure upon the intelligent cooperation of all members of society.

It is only very recently that we have possessed knowledge of the various routes of infection. What we regard today as commonplace information was unknown a few years ago. We hear all classes of society speak of the relation of insects to transmission, of the malarial and yellow fever mosquito, and of the typhoid fly; yet this relationship was only recently discovered. Likewise, tick-transmitted fever and the relation of fleas and lice to disease transmission, although now well known, are recent acquisitions to our knowledge.

That water is one of the principal routes of transmission has been known longer, and methods of water purification are well established. That running water purifies itself has been found to be unsafe as a sanitary precaution in polluted streams, and purification by means of sand filtration is now known to be the only reliable safeguard against polluted water. No city can afford to use raw untreated water from a running stream, for such streams are likely at all times to become polluted. The process of sand filtration is of great interest from the standpoint of the bacteriologist. The object of filtration is to remove any parasitic bacteria that might be present. The sand filter does this very effectively, as has been shown by numerous experiments of cities that use this method. The purification of water by sand filtration is due to the action of non-parasitic bacteria, which become established as a zoogleal mass in the surface layers of the sand. This mass tends to retard the passage of the organisms originally present in the water, and it passes through with a greatly reduced bacterial content. Filtration through sand depends, therefore, upon the bacterial flora of the filter.

Another of the important routes of transmission is the sputum. To control the spread of saliva is one of the most difficult of all sanitary problems. We are accustomed to think of this problem in terms of anti-spitting ordinances, but this is not the only way in which such diseases as are carried by the saliva may be spread. There are, so far as I am aware, no laws against coughing or sneezing which we are bound to respect. Neither can we prevent people from placing their fingers to their lips to moisten them and then immediately after touching door knobs, leaves of books, or from performing any of the thousand and one operations which deposit organisms from the mouth and throat upon surfaces which may be handled by another individual a moment after. This second individual is almost certain to perform the similar operation of moistening his finger tips, and, in so doing, inoculates himself with living virulent organisms.

The spread of such diseases as diphtheria among school children is readily traced to the ease with which they exchange their saliva. Trading lead pencils, which they invariably place in their mouths, drinking from the same cup or from an unsanitary drinking fountain, coughing, sneezing, etc., are but different methods in this transfer of organisms in the saliva of the sick to the well.

There is a growing belief that infection in the case of tuberculosis is due primarily to fine droplets of saliva thrown out by the tuberculosis patient in the operation of coughing or sneezing. These fine droplets are readily demonstrated if one will talk or cough while holding a mirror directly in front of the mouth. These droplets remain suspended in the air for a considerable time, and, since the organisms are kept in a moist condition, they are more apt to retain their virulence than when dried, as in pulverized sputum. Droplet infection, as well as some of the other methods mentioned above, is almost impossible to control. A realization of the dangers from such infection might, however, lead to sanitary precautions which would reduce such dangers to the practical minimum.

Milk furnishes an important route for the transport of disease. The harmful organisms in milk are derived either from the cow herself or from unsanitary methods of handling the milk after it is drawn. Milk is a more dangerous vehicle of disease than water, for the reason that it is a suitable culture medium for many of the bacteria which cause diseases. A few such organisms having been introduced into the milk at the time of milking, or from vessels that had been washed in polluted water, might multiply enormously, and such milk would become accordingly very highly dangerous.

Various standards have been set up by city boards of health concerning the degree of purity required for market milk. It should be borne in mind, however, that from the standpoint of public health all bacteria in milk are not of equal importance. The highest standards of purity permit a certain minimum number of bacteria, usually less than 10,000 per cubic centimeter. The maximum number is usually placed at 500,000 per cubic centimeter. A market milk might readily pass these standards and still contain virulent organisms capable of transmitting diseases.

The bacteriological analysis of milk is of some value in determining the relative conditions of sanitation under which it is produced, but it does not take the place of a rigid inspection of the dairy. A bacteriological analysis of milk is by no means as satisfactory a check on its purity as is the same analysis of a water supply.

The best safeguards for the milk supply is sanitary production. The cows of all dairies supplying milk to the public should be inspected for tuberculosis and health of the udder.

The milker should be a healthy, cleanly individual. The water supply of the dairy must be free from possible sources of pollution, and all bottles and milk vessels must be washed clean and treated with live steam. No bottle should be filled while out on the route, as this is almost sure to result sooner or later in the filling of an infected bottle from some household where there is a case of communicable disease.

The process of pasteurization of milk is often employed to insure against infection, but this process has certain disadvantages. It happens that the parasitic organisms which find their way into milk are all destroyed at the temperatures used in pasteurization, and this, of course, is highly desirable. But the organisms which bring about the normal souring of milk are likewise unable to resist this temperature. This would be very well if it were not for the fact that certain heat resistant bacteria are always present in milk. These forms do not cause either diseases or the souring of milk, but are responsible for decomposition. These forms are not able to multiply for any length of time in unheated milk, for the reason that the acid produced by the milk-souring organisms inhibits their growth. However, when this inhibitory influence is removed through the destruction of the acid producers, the milk, if not kept thoroughly chilled, is liable to decay, and thus form poisonous decomposition products. Pasteurized milk will not sour normally. The danger from such poisonous decomposition products is far greater in pasteurized than in non-pasteurized milk. This method should be resorted to only in extreme cases. Clean milk produced under sanitary conditions is the ideal which should be set up.

The problem of conserving the public health is a problem in which all members of society are obliged to cooperate if the best results are to be obtained. Intelligent cooperation depends upon a knowledge of the known laws of disease transmission. The accompanying chart* illustrates in graphic form the mode of transfer of parasites from one host to another, the means of prevention, and the responsibilities of the various members of society. The duty of every individual is to cooperate in

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*Not reproduced here.

strengthening each barrier and each line of defense against communicable diseases. It has been said that a public utility is a public danger, but this is not necessarily true. The public milk or water supply becomes a public danger only if the public authorities are derelict in the performance of duty. A public commodity may and should be made a public safeguard against disease. This result is, moreover, only to be obtained if the public officer regards his position as a public trust and not a public graft.

FILTRATION AND STERILIZATION OF WATER

BY R. G. TYLER, Adjunct Professor of Highway and Sanitary Engineering, University of Texas

[*Synopsis:* Increased activity in water purification due to enlightenment of public on sanitation; typhoid death rate as affected by water purification; preference of rapid to slow sand filters; what takes place in the filter; necessity of skilled supervision of filtration plants; checking operation with bacteriological tests; contamination of filters; filter trenches; sterilization; sterilization not to be substituted for filtration.]

During the past ten years the purification of public water supplies has received considerably more attention in this state and nation than ever before.

This increased activity has been due to several causes. Legislation has been enacted requiring certain standards of purity for water furnished by municipalities to common carriers. Bacteriological tests are required to be made on these supplies at stated intervals, to guarantee the attainment of this desired purity.

But this has been by far the least important factor in this advance. The demand for safe water supplies has proceeded from an enlightenment of the general public concerning modern ideas of sanitation, and particularly in respect to the spread of water-borne diseases, principally typhoid.

One of the most far-reaching laws in its effect upon purer water supplies in this state is the bill preventing the pollution of streams from sewage contamination. When the effect of this law begins to be felt, there will be a lightening of the load on all filtration purification plants.

By preventing the pollution of sources of supply in this manner, a large number of the municipal supplies of the state will be rendered more safe. But it will be necessary to continue the vigilance at these plants, just as heretofore, as there are many sources of pollution that can not be reached by legislation, however stringent.

The typhoid death rate is the best gauge we have as to improvement in municipal water supplies. There are other sanitary measures which assist in reducing this rate to some extent, but the improvement in water supplies is by far the greater influence. A comparison, therefore, of the typhoid death rate now with that of a decade ago should show the improvement in quality of water supplies during this period.

"It has been shown by Mr. George A. Johnson, M. Am. Soc. C. E., that we may reasonably attribute to water purification an average reduction of 16 deaths per 100,000 population in the 33 cities of over 100,000 population in 1910 that have introduced some form of artificial water purification. On this basis, 2,600 typhoid fever deaths are now avoided each year in these cities alone, and the saving in typhoid fever cases is estimated at 39,000 a year for these same cities."*

Considering the number of smaller cities now supplied with filtered water and the larger cities which have improved their water supplies since the above data was completed (1912), it will appear that the total saving in life in the United States will exceed this amount very considerably.

There are two methods by which a city may improve its water supply. One is to search out purer sources of supply, even at great distances from the point of use. Notable examples of cities doing this are New York City and Los Angeles. The other method is to improve the supply already in use. The population using filtered water in 1914 was 17,291,000, as against 3,160,000 ten years before, or 40.68 per cent of the urban population was served in 1914, as compared with 9.66 per cent at the earlier period.

This improvement in water supply has been brought about mainly by filtration. Here we find modern ideas outstripping the old. The rapid filter is being used in 450 cities, as against about 30 slow sand filters (1914). The slow sand filters are larger, however, and serve nearly one-half the population served by rapid sand filters. Recently, however, some very large

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**Recent Progress and Tendencies in Municipal Water Supply in the United States*, by John W. Alvord, M. Am. Soc. C. E., presented to the International Engineering Congress held at San Francisco, September, 1915.

rapid sand installations have been made, as, for example, the St. Louis plant of 160,000,000 gallons capacity; and several larger ones have been designed, such as that for the Croton water supply of New York, which has a capacity of 320,000,000 gallons. The largest slow sand filter, located at Philadelphia, has a rated capacity of 240,000,000 gallons per day.

The reason for this more rapid growth of the rapid sand filter is enlightening. While the slow sand filter could satisfactorily purify the usually clear waters of the northeastern part of the United States, it could not take care of the waters of the remaining sections of the country, which contain suspended matter in considerable quantities. In fact, several of the larger slow filtration plants have found it necessary to take over some of the features of the rapid sand plant, as, for example, coagulation, which has been introduced at Washington, in spite of the fact that very long sedimentation is also resorted to. It seems very unlikely, from present tendencies, that there will be any great increase in the number of slow sand filtration plants during the next few years. The advantages of the rapid sand filter are so evident and pronounced that it will be used in the majority of new installations. The principal handicap which it has been necessary to overcome in the development of the rapid filter has been the objection raised by the general public against using chemicals in water for drinking purposes. This is a very real obstacle, and an engineer can still bring down a torrent of vituperation on his head by suggesting that chlorine or some of the coagulants be used in a municipal water supply. The public is becoming more familiar with the use of coagulants in water, however, and the fact will undoubtedly influence the continued growth in the number of municipalities adopting the rapid sand filters.

The principal steps in the purification of water with the aid of the rapid filter are coagulation, sedimentation, and filtration. The coagulants ordinarily used are sulphite of alumina (alum) and ferric sulphate with caustic lime. The use of alum is perhaps the more general, on account of its ease of application and comparative absence of danger from harmful effects due to unskillful handling or lack of proper care. The action of the chemical in coagulating the colloidal suspended matter in the water and causing it to be precipitated more rapidly, is familiar to every sanitarian. Some difficulty is encountered, however, in applying the lime uniformly, as it is usually fed dry and the feeder is easily clogged by small pieces of paper from the bag, or otherwise, and it is necessary to titrate the solution of the coagulant at frequent intervals so as to know that the proper proportions are being obtained.

Whatever coagulant is used, it is very desirable to feed it, in a concentrated solution, from an orifice box where the flow can be readily measured and controlled by adjusting the head on the orifice. If piping is used, there is danger of it becoming clogged, and constant attention is necessary to obtain a uniform flow.

After the addition of the coagulant in such a manner as to insure its thorough mixing with the water as it enters the settling basin, a detention period of from three to six hours is allowed to permit the subsidence of a large percentage of the coagulated suspended matter, or flock, as it is usually called. This period of settlement varies with the amount of suspended solids and the nature of these solids, but, if it is less than three hours on waters which are at all turbid, the filters will be overloaded, and the large amount of flock passing over on to the filters will necessitate their beng cleaned at frequent intervals.

The filter itself, consisting of 30 inches to 40 inches of graded sand, with the necessary appliances for introducing the water uniformly and subdrains for removing it quickly, is far from being fool-proof. Here, indeed, skilled supervision is necessary. The filtering material should be disturbed as little as possible, as the regimen of the filter is interrupted every time this bed is broken up. It is necessary to realize that the sedimentation chamber, the filters, and the clear basin must be operated with a due regard to their relation to each other. The water level must be maintained at a constant elevation in the first, and should never be permitted to rise higher than a fixed level in the clear well, so as to keep a constant head on the filters, thereby causing a minimum amount of disturbance in the filtering material, and obtaining more satisfactory results.

These levels can be maintained by floats, attached in a proper manner to the regulating valves. The total head operating upon the filter is measured by the distance from the water surface in the filter to the elevation of the discharge into the clear well, if this is above the water level of this well. It is evident that this head is made up of both positive and negative heads. It is desirable to have the negative head as small as possible, to prevent a separation of dissolved air from the water, in the filters themselves. A total head of 10 feet to 12 feet gives satisfactory results. High heads give greater uniformity of flow.

With the high rates at which these filters are operated, being from 100,000,000 to 125,000,000 gallons per acre per day, it is apparent that frequent cleaning is necessary. This usually is accomplished by reversing the flow of water through them, either with or without the use of compressed air. This washing, which may take place as often as every twelve, but usually twenty-four hours, takes time, and thus cuts down the rate of flow through the filter. It is necessary to wash the sand only for very short intervals, as a rule,—say, five to fifteen minutes,—and the washing should be stopped before the wash water is entirely free from flock, as this is needed to settle back upon the filter so that it may operate properly. The water should then be fed into the filters again before the wash water has drained down to the surface of the sand, so as to prevent disturbing the sand. It takes considerable time, therefore, to operate the various valves necessary in washing the filters. In order to get a higher efficiency, it is not necessary to wash the filters every time they clog and check the flow of the water through them. By simply reversing the flow through them long enough to lift the mat from the top of the bed, then turning the water through again, the filters will work quite well for a time. In this way about half the washings and considerable time may be saved.

From time to time, it becomes necessary to scrape off some of the surface material in cleaning the filters, and this waste is made up from time to time by adding clean sand. The sand furnished by dealers for this purpose is frequently very expensive, if shipped a long distance. The writer has had good success using local materials. After several washings, this sand will arrange itself from the action of the water, with the finest material on the surface and increasing in size towards the bottom. The material which is too fine may then be scraped off. Until this fine material has been removed, the surface of the filter will pack and clog quickly, so that it may be necessary to reverse the flow at intervals just enough to lift the sand, when the flow will again start.

No particular points need be mentioned in regard to the clear well, further than that it should be large enough so that it will carry over in case the filters have to be shut down for repairs. It, like the sedimentation basin, should be built with the bottom sloping to a drain, so as to facilitate washing.

The operation of the filter plant must be checked up by bacteriological tests both on the raw and on the filtered water. It is not proof that the bacteria are removed, simply because the suspended matter has been intercepted. The writer has observed one instance where the water from the sedimentation basin was very low in bacteria, while the effluent bacterial count for the filters was high. This was caused by the filter having become inoculated with some species of bacteria, which had multiplied to such an extent that the effluent from the filter contained more bacteria than the influent. This condition would not have become known, and a false sense of security would have been felt, if daily tests had not been made, both on the raw and on the filtered water.

A filter may very easily become inoculated as mentioned above, either by bacteria or by algae. In the latter case, the bed becomes matted, and the algae can not easily be removed by washing. Where this condition is in effect, it may be remedied by washing with copper sulphate or treating with chlorine. More will be said of the latter treatment later.

Before leaving the subject of filters, a few remarks are in order concerning what is known as filter galleries or filter trenches. This type of filter is not very common, but it so happens that Austin is supplied by water from four of these trenches. Here a concrete box without a bottom is sunk some 20 feet to 30 feet into the sand adjacent to the river. Quite recently an opportunity was offered the writer to study the results obtained by the use of these trenches, in trying to locate the source of pollution of the water, which had become contaminated in some unknown way. During the investigation which followed, some quite interesting facts were brought out. The filters are located at right angles to each other. One running north and south has its south end quite near the river; the other is several hundred feet away from the river and parallel to it. It developed from tests made by the State Board of Health and the Food-Dairy Commission that the water which reaches the filters does not come from the river directly, but appears to be from an underflow parallel to the river. It was at first thought that the entire sand bed of the river was parallel, but this was found not to be the case, as the water for a considerable time would be low in bacteria, and then all at once it would increase to a high figure. The final conclusion reached as to the source of contamination was that it probably was due to water seeping into one of the filters from a very small pond in the immediate vicinity of the filters and at a somewhat higher elevation.

In the course of the investigation, the fact was impressed very forcibly upon the writer that one disadvantage of this type of filter is the many possible sources of contamination necessary to be guarded against. The wells in the vicinity of the trenches were found to have a higher chlorine content than the filtered water, and the soil adjacent to these wells appears to be badly contaminated from cesspools and surface toilets.

Then there were several possible sources of surface pollution following rainfalls. The most serious objection to the filter trench, however, appears to be the inaccessibility of its various component parts, and the lack of control over the different steps in the purification such as is had with the rapid filter, and the impracticability of cleansing the sand when contaminated. The chief advantage lies in the smaller cost of operation and maintenance. The advisability of installing a filtering trench is a question which has to be determined upon the merits of the individual case, but the above disadvantages should be kept in mind in deciding this question.

Undoubtedly, the greatest advance in water purification made in recent years is in the application of a sterilizing agent to the water to remove the bacteria. Several of these agents have been used with varying degrees of success. The ultra-violet ray, ozone, hypochlorite of lime, liquid chlorine, and ammonia have been used at different plants. The first two, which have been used in Europe more or less, have not proven economical in this country. Hypochlorite of lime, or common "bleach," has been used extensively, and with very satisfactory results. Since it is usually accepted that the sterilization brought about with this chemical is due to the available chlorine present, it appears more desirable to use the chlorine in liquid form. The amount used varies, of course, with the condition of the water to be treated. With filtered water, from 1 to 4 parts per million appears to be sufficient. Sometimes it is desirable, when used in conjunction with rapid sand filters, to apply the chlorine ahead of the filter to oxidize any algae which may be in the water. The writer has had occasion to apply chlorine in this way to kill the algae with which the filters had become badly contaminated. An application of copper sulphate had not been successful in eliminating these, but, three days after starting the chlorine treatment, the algae appeared to have been completely killed.

It would seem that there is a large field of usefulness for chlorine disinfection in the small towns, which do not use filters. If a surface supply is used, in the spring and summer algae accumulate, and produce tastes, odors, and discoloration in the water. The commonly encountered "fishy" taste is due to a species of algae. These objectionable features may be easily and economically removed by chlorine or copper sulphate.

If deep wells are used, these often become contaminated from surface water or otherwise, and even when encased, as is usually the case, instances have come to the writer's attention where the waters contained more bacteria than neighboring surface supplies. Here, again, the use of chlorine is recommended.

These remarks must not be construed as meaning that chlorination can take the place of filtration, for such is not the case. There are many small towns, however, that think they can not afford filters that can afford the $300 to $800 necessary to install a chlorinating plant, with an operating cost of from $0.25 to $0.75 per million gallons of water treated.

During the last few months, chlorine mixed with anhydrous ammonia in equal proportions has been used. It is claimed that satisfactory results were obtained, and that the combination was cheaper than straight chlorine, on account of the low cost of the anhydrous ammonia. Some precautions must be taken when using the above mixture.

In conclusion, it appears that there is a growing tendency to overconfidence in the results obtained by filters, etc., and that many very bad waters are being treated and used when, in reality, a purer though perhaps more distant source of supply would be preferable. The guardians of the public health shoulder a heavy responsibility with reference to their water supply, and they should remember that, for every death from typhoid or other water-borne diseases, it is probable that some official has not attended to his duty and done all he could for the protection of his water supply.

SEPTIC AND IMHOFF TANKS

BY M. C. WELBORN, City Engineer, Austin, Texas

[*Synopsis:* Sludge problem as prime factor in disposal plant design; development of one and two-story tanks; degree of purification obtained; objections to one-story tanks, and advantages of Imhoff tanks; gas production; type of sludge produced.]

In all sewage disposal systems or processes, the sludge problem has been found to be the most difficult of solution of all the problems encountered. The principal difficulty is not so much in separating the solids from the liquids, but in finally disposing of the solids or sludge at a reasonable expense and without creating a nuisance.

It is an easy matter so to treat sewage with chemicals that a very large percentage of the suspended solids will be precipitated to the bottom of the tank and thus removed from the liquid, but, in finally disposing of the resulting sludge, we find we have to dispose, not only of the solid matter that was originally in the sewage, but also of the added amount of chemicals in the sludge, otherwise bacterial action is retarded or stopped altogether, and, unless this sludge is dried or removed at once, a serious nuisance is created.

Some cities located on or near a seacoast dispose of this sludge by loading it into barges and carrying it out to sea a distance of thirty or forty miles, while other cities dispose of it by pressing and drying and then either burning it in an incinerator or disposing of it as a fertilizer for land.

In 1860, a Frenchman named Mouras discovered that sewage sludge would be partially liquefied if allowed to remain long enough in a closed vessel, and at that time he designed what he called an "automatic scavenger," which was really an overflow cesspool. This apparatus was a closed vault with a water seal through which the sewage was allowed to pass. On account of the low velocity of the sewage through this vault, the solid matter settled to the bottom, where the process now known as "septic action" took place.

From 1860 up to the present time, many different types of sedimentation tanks have been built, in which was utilized the self-purifying action that takes place in sewage sludge. Among the noted experimenters in this line was Prof. A. N. Talbot, of the University of Illinois, who, in 1894, built a sewage tank for Urbana, Ill., in which the liquefying anaerobic action was observed, and he afterward designed and built a larger plant, with this definite end in view, for Champaign, Ill.

In 1895, Donald Cameron built, in Exeter, England, a water-tight covered basin for the treatment of the sewage of a portion of that city by anaerobic purification, and gave to it the picturesque name of "septic tank." This tank was covered, and had a submerged inlet and outlet, and every precaution was taken to make it air tight, in order to give the anaerobic bacteria the best possible chance to get in their work. This tank worked well, and Cameron promptly had the whole thing, tank and process, patented, even down to the anaerobic bacteria.

These patents immediately started trouble. The public, especially the engineering profession, felt that Cameron's system was only a slightly varied process for the utilization of an old principle, and that it should not have been patented, and these patents were generally ignored. Many suits were brought by the Cameron people for infringement of their patents, some of which possibly were pending when these patents expired a few years ago.

While the writer believes that the value of Cameron's discoveries and inventions has been very much overrated, the litigation resulting from infringements of his patents served to advertise the process widely, and to stimulate historical and scientific research work, which resulted in the compiling and publishing of an immense amount of data in regard to the "Antecedents of the Septic Tank" and to further perfecting the different processes of sewage purification, in search for some process in which infringements of the Cameron patents could be avoided.

Efforts have been made to remove the solids from sewage by allowing it to remain quiet for several hours in large tanks, and some plants have been built to operate in this way, but the writer does not know of any such plants in existence at this time. It is now the universal custom to operate sedimentation tanks by the "continuous flow" method. In practically all of the plants where septic action is depended upon as a step in the process of purifying sewage, tanks are built for the twofold purpose of separating the solids from the liquids and of storing the solids for considerable periods under conditions most favorable for septic action.

The city of Baltimore, Md., recently constructed a sewage disposal plant in the operation of which the sludge was removed from the sedimentation tanks, or "digesting chambers," through which no sewage was allowed to flow during the digesting process. When the writer visited this plant in October, 1913, he found conditions there far from satisfactory. The walks around the margins of the sludge tanks were covered with worms that had developed in the sludge and had crawled out on to the surface and on to the walks, and the air was so filled with myriads of flies that it was inadvisable to open one's mouth to talk, and even breathing was difficult. The odor of sulphureted hydrogen was very strong. Sludge from these digesting tanks which had been on the sludge drying bed for six weeks had dried only sufficiently to begin to crack about the edges. The system then in use has since been abandoned, and hydrolytic and Imhoff tanks have been installed.

The efficiency of a septic tank is judged by its action in removing the suspended solids and liquefying the solids removed.

In order to remove the true suspended solids, it is necessary to slacken the velocity of the sewage to less than 0.1 ft. per second, and in some plants the velocity has been reduced to less than 0.01 ft. per second. In the Atlanta plant, the velocity is reduced to 0.5 ft. per minute, and this velocity, with a three-hour detention period, permits the removal of from 60 to 85 per cent of the total solids, and practically all of the settable solids.

Septic action is the decomposition through bacterial agencies of the sludge in the bottom of a sedimentation tank, with the consequent production of gases and the breaking up and partial liquefaction of the solid matter.

This action takes place whenever the sludge in the bottom of a settling tank is allowed to remain a considerable length of time. It begins a few days after the sewage starts flowing through the tank, and under favorable conditions reaches its full development within a month or six weeks. The decomposition and liquefaction of the organic matter are brought about chiefly through the action of what are known as "anaerobic" bacteria.

While it may be that the organic matter in solution is also broken up to a certain extent, this action is confined chiefly to the solid matter, and its most beneficial results are in the reduction of the amount of solids which have settled to the bottom of the tank, and in the working over of these solids till they are in a state not subject to further putrefaction.

There is no doubt that a great amount of the deposited matter is liquefied, but this liquefying action has been and is still frequently very much overrated. It is still a common thing to meet with persons boosting some patent apparatus or process that will positively liquefy every particle of the solid matter in the sewage, will kill all the bacteria, and will turn out an effluent clear and sparkling and pure as spring water, and will continue to operate forever without any attention or maintenance expense. Before you allow yourself to be taken in by one of these artists, it will be well to remind yourself of nature's law of the conservation of matter, and remember that in all manufacturing processes there is always a certain amount of by-products.

The percentage of solids liquefied by septic action varies, because of the varying character of the sewage of different localities, because of different types of tanks, different seasons of the year, different climates, etc., but experience with well-constructed tanks has shown that it is possible to obtain a liquefaction of 40 per cent of the settled solids. This rate, however, is far above the average. An average for the year round for any one plant of 25 per cent would be considered good.

Of the suspended solids in the ordinary domestic sewage of this country, it is possible to remove by sedimentation as much as 80 per cent, though such a high rate is exceptional and 60 per cent might be considered a fair average. In regard to the removal of solids from sewage, the action of the old style septic tank is sometimes negative. In summer, when fermentation is active, the rising gas bubbles may and often do cause the discharge of considerably more solid matter than enters the tank. Of sixteen experiments made on eight different tanks in Ohio in the summers of 1906 and 1907, ten showed negative results ranging from 0 to 43 per cent.

Until recently, it was the custom to build septic tanks rectangular in shape, rather shallow (from 6 ft. to 8 ft. in depth), and so divided with partitions and baffle walls as to cause the sewage to flow through practically the whole depth of the tank and to come into close contact with the decomposing sludge in the bottom of the tank. Formerly it was considered necessary to hold the sewage in the tanks for from 6 to 12 hours, and in some cases as long as 24 hours, or even 30 hours; but it is now customary to pass it through the tanks in 4 hours or less. These old style tanks had many objectionable features, some of which were:

(1) The gas bubbling up from the decomposing sludge kept the flowing liquid constantly agitated, interfering with the sedimentation process.

(2) It was necessary to shut down the tank, drain off the liquid, and shovel out the sludge when it became necessary to clean the tank.

(3) The sludge, after being removed, was hard to handle and slow to dry.

(4) The intimate mixing of fresh with stale sewage and the long retention period caused the generation of sulphureted hydrogen, causing such disagreeable odors that the plant had to be far removed from all human habitation, causing great expense for long lines of outfall sewer.

The first two objections were overcome in the hydrolytic tank developed by Dr. Travis, a large installation of which was built at Norwich, England, about 1907. This tank is divided into three sections, two sedimentation chambers communicating with a reduction chamber below and between them by narrow ports through which the sludge passes. One-fifth of the sewage enters the reduction chamber directly, the other four-fifths passing through the sedimentation chambers. The designer of this tank probably had definite knowledge of the principle of liquefaction of sewage sludge later demonstrated by Calmette, who showed by experiment that the proper liquefying action takes place best in flowing sewage. Provision was made in the construction of these tanks for the drawing off of the sludge from the bottom of the tank without draining the tank or stopping the flow of the sewage through it.

All of these principal objections to the old-fashioned septic tank have been overcome by Dr. Imhoff in a tank designed by him which bears his name. The Imhoff tank is from 24 ft. to 30 ft. in depth, has a hopper-shaped bottom, and is divided into two compartments, the upper one serving as a sedimentation chamber through which the sewage passes, and the lower one serving as a liquefying chamber. The sewage passes rather rapidly through the upper chamber, and is kept fresh and free from septic action while the solids settle through the slots to the compartment below. These slots are so "trapped" that no gas can escape through the flowing liquid, but the gases generated by the decomposition going on in the reduction chamber are carried to the outer air through special vents. The proportion of sludge digested or liquefied is about the same as in the ordinary septic tanks, but the residue is quite different. The sludge which accumulates is compact and low in water content (75 per cent to 80 per cent), on account of the pressure to which it is subjected; and, on this account and because of the considerable amount of gas absorbed, the sludge dries very rapidly, and can be disposed of on a very small area of ground. Most important of all is the freedom from odor of the plant as a whole, which is in marked contrast with the offensive conditions that generally surround the ordinary septic tank installation. The gases liberated from the Atlanta tanks are composed of nitrogen, carbon dioxide, hydrogen, and methane, and burn freely, producing an average of 700 B. T. U. At this plant, this gas is being used for all purposes in the laboratory and for cooking and heating in the chemist's residence. Mr. Hammon, the resident chemist at the Atlanta plants, estimates the gas production to be at the rate of 3,750 cu. ft. per million gallons of sewage treated. In this county of high-priced fuel, this gas alone might prove to be an item of considerable value, if properly conserved.

A few days after visiting the Baltimore plant in October, 1913, the writer visited the Atlanta plants. Things here were quite different from those observed at the former plant. There was no disagreeable odor, no worms or flies, and sludge which had been on the drying bed one week was dry enough to be removed, and a portion of it was taken up, wrapped in a newspaper, and brought to Austin in the writer's suit case, and has been preserved and is exhibited here today. While this specimen is now more than three years old, and is slightly dryer than when it was taken from the drying bed, it was no more offensive at that time than it is today.