McCLENAHAN

Sewage Purification Plans for Residences & Small Institutions

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SEWAGE PURIFICATION PLANS FOR RESIDENCES AND SMALL INSTITUTIONS

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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Sewage Purification Plans for Residences

and

Small Institutions.

Since the general introduction, some thirty years ago, of the separate water carriage system of sewage, sanitary science has made remarkable progress both in the mechanical appliances used, and in the matter of treating the sewage itself. The modern bath room is in many respects a model of cleanliness. The old dry closet and privy vault have been discarded in most large cities. In these cities, the problem of sewage disposal has been solved as far as the private individual is concerned, but still remains as a serious problem for the city.

The sewage as it comes from the sewer is yet too foul to turn into streams or lakes which afford a water supply to people below. It is becoming the general opinion of sanitarians today that no dilution, however great, will guarantee absolute safety to cities or individuals drawing their drinking supplies from the same stream. If the stream is small so that the dilution is small, the odors which may arise from the stream may become very offensive. Floods stir up this offensive sediment and carry it long distances. Since this sediment is rich in bacterial life, it will always be a menace to the life and health of water users below. Typhoid is known to have been carried long distances during floods which have stirred up this bacterial slime.

If no stream is at hand or if the stream be a wet weather creek, the problem of the disposal of the sewage becomes very much more difficult, the more populous the country around, the more difficult the solution. The solutions of these perplexing problems have been varied as to methods used and as to the success attained. The proper

solution of any one problem is evidently so dependent on local conditions, that it is hard to point to what has been done in a given place under given conditions, and say that the same system of sewage disposal will work under different conditions, at another place. As the mass of data in regard to the merits of the various plants and systems already in use increases, we will be better able to design for any given condition.

The study of bacteriology has done much toward clearing up some of the uncertainties in regard to the efficiencies of the various methods and processes of sewage disposal. Incidentally this study has advanced our knowledge of bacteriology very materially. On account of this study of sewage treatment, we know more about the function and use of bacteria as destroyers of organic matter, as well as their danger as agents of disease. It has been pretty well established that as soon as this organic matter has been used up and changed into inorganic compounds, bacteria will die out of their own accord, due to starvation and it is the desire of the sanitarian to get rid of the organic matter, knowing as he does, that by so doing, he incidentally gets rid of the bacteria. The present methods of treating sewage for the disposal of the organic wastes, may be roughly divided into chemical, mechanical and bacterial methods. These may be used either alone or in various combinations, and are themselves divisible into several different methods. The various methods and their application for isolated houses or institutions will be taken up in this thesis.

The Importance of a Method for Sewage Disposal.

In the case of isolated dwellings, the importance of the proper disposal of household and human wastes, has not in the past received as great notice as the subject deserves. Undoubtedly many lives have been sacrificed to the ignorance or carelessness of people in general in regard to the disposal of slops and excrement. Properly constructed and if not too close to a well, or connected by open fissures therewith, a privy vault may be safe enough, as is evidenced by the fact that they have been used so generally with impunity. There is, however, the possibility of the contamination of the well water supply. Especially may they be a source of danger to health on account of flies carrying the filth to our dinner tables. Prof. Sedgwick has very clearly shown by means of a fly, which had been in such a place, walking on a plate of gelatine, how very dangerous such places may be. In a couple of days, the plate of gelatine showed the fly tracks as colonies of bacteria resembling patches of mould. Now it is evident, that if the fly could carry bacteria to the plate of gelatine, he could do the same thing to a plate of food on our tables.

Colonel Waring in his book entitled, "Modern Methods of Sewage Disposal", says: "The belief prevails that the chief source of offensiveness of sewage lies in the solid fecal matter that it contains. The fact is that fecal matter is of far less consequence than urine and the waste of the kitchen sink. The chief source of this waste matter is the food prepared for the use of the people and either rejected in the course of preparation or actually consumed. To this are to be added the soilings of linen and the soap used in washing and bathing and the washing of dishes and kitchen utensils. Coarse garbage and swill are not included. The excretions of the people and

the kitchen and pantry wastes are the most important in quantity and most serious in quality. From the view point of the sanitarian they are about equally important. The kitchen waste is generally assumed to be the most abundant. The difference between them is a difference of condition rather than in constituents. One is further advanced in decomposition than the other but both are moving along the same line, and they will soon become indistinguishable. A cask of water closet matter and a cask of kitchen sink matter will after a short time be the same in appearance, in odor, and in constituents. They will be equally offensive and equally dangerous save that the closet matter may have been originally infected with disease germs,-such as typhoid bacillus- and the other not infected. Even this distinction is not likely to continue in any practicable treatment of the two. They must therefore be regarded as demanding in all respects the same care and precautions." This long quotation is used to show how present authorities regard kitchen wastes which are too often thrown into open drains or cesspools and not infrequently thrown upon the ground near wells. Analysis of such well waters made by the State Water Survey show polution in many cases to the extent of several thousand bacteria per cubic centimeter, (about equal to a cubic 3/8 in.) whereas good well waters should not have over 200 bacteria per cubic centimeter to be considered at all safe, although even this many may be dangerous if of pathogenic origin. The point to be emphasized is, that bacteria live and grow in the presence of the proper food supply and that it makes very little difference whether this supply comes from the human body or from the kitchen. The importance of a proper disposal of all wastes is well emphasized by many cases of the spread of typhoid fever from wells poluted by

slops thrown indiscriminately upon the ground and then washed into the wells by rains .

Filtration through the soil layers is one of the best means of purification of water, yet the danger of the contamination of wells through the soil may be very great. Contamination of these wells may take place in one or both of two ways; First, directly through the soil in which case the disease producing bacteria are themselves carried right through the earth into the well; Secondly, the contamination itself, that is, the seeding germ may not come from a vault, cesspool or such like at all, but may be washed in at the top of the well and on account of the liquids and finely divided matter which has filtered through the ground into the well from the privy vault or cesspool, the germ finds a suitable place in which to multiply and grow until the whole well may become teeming with millions of disease germs. In this way, liquids from vaults or cesspools may be very dangerous although the bacteria in these vaults may have been filtered out.

Just how far bacteria may be carried through the earth is hard to say. No hard and fast rule can be laid down. Some authorities say not over one hundred feet, but it is evidently so dependent on earth structure, the saturation of the soil layers and the quantity of water pumped from the well, that the exact distance necessary for safety is very indefinite. A well aerated, unsaturated, sandy soil, will more or less purify the sewage in its passage through the ground, while a well saturated soil will not do so to any great extent. If the ground water level is high and there is a great deal of water pumped at times from the well, the extent of the circle of contamination may be increased by a washing of the soils into underground channels and veins. Again, the natural flow of the ground water will have its effect upon

the distance and the direction of contamination. However, the most likely means of contamination is through fissures or subterranean channels in the rocks, or between the rock layers or not infrequently through holes made by earth worms, crabs, etc. A thin sheet of sand or gravel lying between two harder layers of rock or clay, if thoroughly saturated and flowing as a spring, will be in effect a fissure between the rocks, because of its saturation and because of high velocities through it. It may be said that, generally speaking, earth and fine sand will filter out the bacteria in the first few feet of distance, but it is through these holes and fissures and saturated sand layers that polution is most likely to occur.

To show the danger which may arise from this source, we might cite the notable example of Lausanne Switzerland,where an epidemic of typhoid was traced to the infection of the city well water supply from a polluted brook a mile away on the other side of the mountain, but which was connected therewith by an underground passage.

Besides the danger to health from an improper disposal of wastes, we should consider the esthetic advantage and convenience of a well designed water closet system. Properly installed, it does away with the foul smelling, bad appearing privy house. It is a great deal more convenient for use in the winter. Besides it affords a system by which the kitchen wastes can be removed without serious trouble. These are facts that ought to appeal to every householder, the farmer no less than the city man. If, however, the system is to be used by the farmer or suburbanite, he must find some means of disposing of the sewage after it leaves the house. The city man finds the sewer at hand and properly enough empties the sewage into it. The farmer or suburbanite on the other hand must provide his own system of disposal

to prevent a nuisance or a menace to health.

It is the purpose of this thesis to show some plans uses at present, to describe methods and to suggest several plans that might be applicable to dwelling houses and small institutions for disposing of their wastes.

Methods in Use.

The three methods of disposing of sewage as mentioned above are chemical, mechanical and bacterial. A general discription of these methods will be taken up.

Chemical Methods.

Chemical methods are so expensive that they are scarcely applicable to the small plants under consideration and will be omitted. It may be said in passing that several other less expensive methods give as good or better results than most of the chemical methods in use.

Mechanical Methods.

Mechanical methods may be subdivided into the four classes:

First, Method by Screening out the Solids;

Second, " " Dilution with large quantities of water;

Third, " " Sedimentation at High Velocities;

Fourth, " " " " " Low " "

We will take them up for discussion in their order.

Method by Screening.

This method is a very simple one and does not give much purification. It is, however, of use in certain cases, of the city sewage especially, where a combined system of taking care of the sewage and the storm water flow from the street surface is carried by the same sewer. In this case the sticks and coarse floating matter are screened out in

order to keep them out of the other parts of the purification plant if any are used. The mesh used will depend upon the size of particles it is desired to retain thereon. Screens have been used varying from 3/8 inch up to 4 inches. The screens are always a source of trouble and require frequent cleaning. With the kind of sewage coming from a private house or small institution where no surface rain water is admitted to the system, it is doubtful whether it pays to use screens at all, because such things are likely to receive very little attention after they have once been installed.

Method by Dilution.

If a dwelling or institution be situated on a large stream in a district not too populous, the method of emptying directly into the stream may be used satisfactorily. It should be understood here that dilution does not purify the sewage to any large extent, except after a considerable lapse of time, and that it should not be depended upon to do much purification but merely to remove the sewage and to prevent a nuisance. Just how large the stream should be is rather hard to determine and is somewhat dependent on local conditions. Some authorities, notably Folwell, say that the stream flow should be from 1500 to 3500 gallons per capita per day. It must be remembered that this is to be the least dilution to be allowed and should therefore be the dry weather flow and not the normal flow. For Illinois, we may consider that one square mile will yield about 1 cu. ft. per second flow as a normal flow. At thirty five hundred gallons per capita per day, it would require about 1/2 a square mile to dilute the sewage of one hundred people under normal flow. Dry weather would reduce this to nothing in most places. The flow should be large enough to prevent the sewage clinging to the banks of the stream. The "Boneyard", a small stream running through the university campus and the twin cities of

Champaign and Urbana, has a normal flow of about 4 cu. ft. per second from about 4 sq. mi. area. Several years ago, it received the sewage from about 500 people without a great deal of complaint except in dry weather when the flow was reduced down to less than 1/2 cu. ft. per second.

Care must be used in designing the outfalls so that they will carry the sewage into the current and so that stagnant pools of sewage will not form to putrify and become offensive.

A method which is adaptable to much smaller dilutions and has proven quite successful is to treat the sewage in a sewage or bacterial tank as preliminary to turning it into the stream. This subject of the sewage tank will be taken up later, but it may here be stated that its purpose is to hold back the solid suspended matter, and by the bacterial action going on therein to change more or less of the suspended organic matter into soluble or finely divided suspended matter. It is not in itself a complete purification process, but it is a step towards purification in that it changes the sewage into a less objectionable form. Insoluble and floating organic matter from untreated sewage may collect along the banks and bottom of the stream and putrefy. This mass of decaying matter is a hot bed for bacterial growth, and causes the nuisance so often noticed about the outlets of sewers. It is the purpose of the sewage tank to prevent this collection of filth by partially liquifying it and by retaining the rest in the tank as a sludge deposit.

Since the ultimate purpose of all sewage purification is to get the organic matter into stable forms and since most of these forms require the sewage to be oxidized, the amount of oxygen required to oxidize the sewage will be an indication of its putrescibility. Experiments at Columbus, Ohio, seem to show that it requires about 20% less

oxygen to oxidize the effluent of a sewage tank. That is, it will require only 80% as much water of dilution. Figuring on this basis, it would require from 1000 to 2500 gallons per capita per day to dilute the effluent from the sewage tank.

Sedimentation at High Velocities.

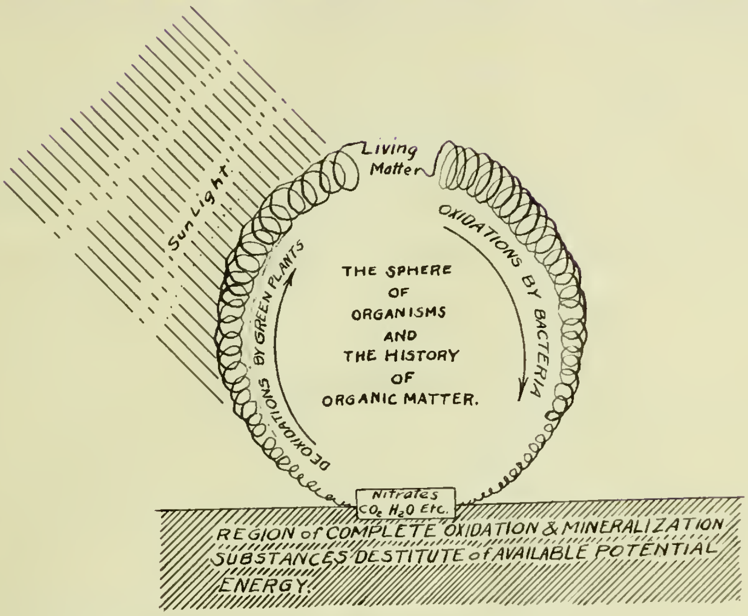
All sewage contains more or less mineral matter which although not ordinarily harmful in streams, is undesirable in large quantities in sewage treated by other processes. This mineral matter consists of sand, soil and hard mineral substances which are accidently washed into the sewer. Whenever it is used, the grit chamber is therefore usually preliminary to other methods of treatment. Since the organic matter has more nearly the same weight per unit volume as water, than has sand and other grit, a reduction of the velocity of flow, a given amount will cause a larger percentage of the grit to precipitate to the bottom than of the organic matter. If the flow in the sewer is, say 1 1/2 feet per second, a reduction to say .1 or.2 feet a second actual velocity will materially reduce the mineral matter in suspension without effecting the organic matter greatly.

Plain Sedimentation Low Velocities.

(See Sewage Tanks)

Bacterial Processes.

Bacterial processes depend upon the rapid growth of bacteria in the presence of organic matter to reduce this matter to forms which can no longer furnish food for other bacterial growth. This method is therefore a natural one which has been adopted by man for purification purposes by furnishing a suitable habitat for the bacterial growth.



Theory of Bacterial Decomposition upon which Process is Based.

In the diagram above taken from Prescott and Winslow's book entitled, "Elements of Water Bacteriology", the process of life is clearly shown. Plants in the presence of sunlight build up the inorganic into organic compounds for the use of animals at the top. From here on, the process is a tearing down process by the agency of bacteria so that the matter is again returned to the inorganic state of substances. It will be noticed that bacterial action is on the dark side of the cycle of life. This is one of the conditions for active bacterial growth, and is one reason for covering sewage tanks and filters, although the most important one is to keep the temperature at such a

point that the bacteria will do their best. After organic matter has been reduced to inorganic compounds, bacterial life dies out and plant life begins. So the cycle of life repeats itself. Plant life may be short circuited over to the bacterial side of the cycle of life without being utilized by animals, as in the case of a rotting apple.

Bacteriologists divide bacteria into two general classes and an intermediate class, namely: Aerobic, Anaerobic and Facultative.

Aerobic bacteria require oxygen(air) to carry on their work effectively. Since their action is principally oxidation, we may call them oxidizing bacteria and their action an oxidation process.

Anaerobic bacteria seem to have the ability to attack solid organic matter and by a process of digestion to change it into soluble or gaseous forms or into a very finely divided solid. They require no oxygen to accomplish this end, and in fact, they seem to work better when oxygen is absent.

Facultative bacteria compose by far the largest class(90% of all bacteria). They are not well understood, but they seem to be able to accomodate themselves to either condition of air supply and are seemingly either oxidizing or reducing agents as circumstances permit(according to Abbot). Since they occupy this dual position, we consider them as aerobes or anaerobes, according to the products they throw off and for our purposes, divide the whole field of bacteriology into the two general processes of reduction and oxidation. In point of precedence, the reduction process must come first. In fact, oxidation of solids by aerobes takes place very slowly and is hardly worth considering .

Reduction Process.

A reduction process occurs in sewage tanks and in those filters (roughing) which are not aerated but are kept continuously covered with sewage. Anaerobic action may also take place in any of the other processes described below, if the air supply is not very abundant. Reduction processes are likely to be accompanied by foul odors. It is anaerobic action which causes the foul smells about privies and manure piles. For this reason, good ventilation should be provided above sewage tanks and roughing filters so as to prevent the collection of these foul odors.

The Sewage Tank.

The sewage tank and the sedimentation tank are very nearly the same in construction, but differ in their action. In both, the velocity of flow is very small. Both are made to hold from 8 to 24 hours flow of sewage. In both, the suspended matter settles out and is left in the tank either as a sludge deposit or as a mat on top of the sewage. The principle difference is in the way the two tanks are operated. The sedimentation tank is cleaned out every few days. Both organic and inorganic matter is taken out at this time so that the purification obtained is more a change of the place of the sewage solids than a change of their composition. About 50% of the suspended matter is thus removed. The sewage tank, on the other hand, is cleaned very rarely, and there is a radical change in the composition of the sewage. Anaerobic action is the most prevalent therein, but does not seem to be the exclusive action. The lighter material gathers at the top and develops into a scum or mat. The heavier substances settle to the bottom. The inlet and outlet should be so constructed as not to disturb these settlings. In a week or so after the tank has been started,

depending upon the season and quality of sewage, anaerobic action starts up and the solids are rapidly changed into liquids, gases and precipitate. After some time, the ebullition of gas may be quite violent, in which case the precipitate which collects on the bottom of the tank, may be so riled up that some of it will be carried out of the tank. This precipitate, if the process is not carried too far, is inorganic and rather harmless, but if the process be long continued it may contain an insoluble black organic substance which is very troublesome and hard to treat. Overtreated sewage is difficult to handle by other bacterial processes, not only because of this black precipitate which is carried out of the tank at times, but also on account of a toxic condition in which the supernatant liquid may be left by the anaerobic bacteria. There seems to be considerable lee way, however, in regard to the time the anaerobic action may be allowed to continue so that capacities from 8 to 24 hours flow of sewage seem to make very little difference in this respect. The proper size of tank to get the proper treatment will be taken up further under design. From 30% to 50% of the organic matter is liquified by this treatment of sewage.

The Roughing Filter.

The roughing filter consists of layers of coarse material like coke, broken stone, tile, brick or slag, or gravel, through which the sewage passes in a continuous flow, either upward or downward according to design. This filter seems to have an advantage over the sewage tank in that it takes out more of the fats and grease, but it has the serious disadvantage of having to be cleaned quite often. On account of the clogging of the filter, roughing filters are designed to operate under a loss of head. The fine material should be screened out of the coarse material of which the filter is made so as to leave

the voids in the filter as great as possible. For the same reason the material should not be of such a nature as to disintegrate under the action of the sewage liquids. Rates have been uses from 1.5 to 3 million gallons per acre per day equivalent to from 310 to 620 gallons per square yard per day. Coke Strainers at Columbus, Ohio, when used at these rates showed a reduction of suspended matter equal to about 65% to 85% of the original content, but varied a good deal because the filter becoming much clogged would act under a high head of water which would break through in streams and so there would be little purification of the raw sewage for a time.

Oxidation Processes.

As has been said before, oxidation of sewage is the ultimate purpose of purification. It is at least the most important end sought. The oxidation processes are therefore the most important ones where a comparatively pure water is desired at the outlet. All these processes involve a means of getting the sewage into intimate contact with the air. There are two general methods of doing this; first, by filling the pores of the filtering materials alternately with sewage and air; second, by having the pores so large and the ventilation so good and the sewage sprinkled on in such quantities that it flows over the stones of the filter in a thin film which readily absorbs the air from the filter spaces and supplies it to the aerobes.

The methods in use for oxidizing the sewage bacterially may also be classed under the following heads:

1, Irrigation: Surface (or broad)
Subsurface

2, Intermittent Downward Filtration,

3, Contact Beds,

4, Sprinkling Filters (Percolation Beds)

Broad Irrigation.

Ordinarily, this method is used without preliminary treatment of any kind. This is the oldest process of purification and when first introduced, it was believed that it would prove profitable to truck farmers because of the manurial value of the sewage. In very few cases has this been the case because of the great dilution and the trouble experienced in wet weather of taking care of the surplus water. This generally results either in having the crops drowned out or else in having the sewage improperly treated. If it is attempted to raise crops on the land, they should be such as will evaporate large quantities of water. Otherwise, large tracts of land will be required. Italian rye grass is said to be one of best crops to grow, yielding as it does some six or seven crops a year. Other crops often used are mint, colza, wheat and rye. A plot may be sown in rye for two or three years and then plowed up and put in vegetables for a year with advantage. Other crops may be raised with varying success. The amount of land which will be required and the value of sewage to the crop can only be determined by experiment. Reeds, sedges, duck weed, rushes, white and yellow lilies, frogbite, water ranunculus, liverwort and sunflower are capable of absorbing large quantities of organic matter and may be used in places. Osiers and especially the American waterweed, anacharis, are very good but the latter will spread very rapidly and should be used only in special cases.

Venable states that for stiff clays one acre may be required for every 25 people, while for loamy gravel one acre might serve 100 people.

For penitentiaries, reformatories, poor houses, asylums, etc., broad irrigation might be used to advantage, because the labor would

cost little or nothing for tending the fields. For dry countries too it might be profitable to use the sewage, not so much for its manurial value as for irrigation purposes.

The following from Professor Robinson's book on "Sewage and Sewage Disposal" gives an idea of how the system is used in England:

"After the sewage is delivered on the land at the outfall it is distributed by main carriers, either of earthenware or concrete or of bricks in cement. These are placed on a contour and are regulated by sluices and stops, so as to command the area to be irrigated, the sewage being distributed over the surface by carriers made in the ground. Any pipe carriers under ground which convey the sewage from one point to another should be kept low enough to prevent disturbances when the surface is being manipulated either with the plow, or otherwise. There are several methods for distributing sewage over the surface of land, which are largely regulated by the purpose to which the land is to be devoted."

"In the ridge and furrow system the land is prepared in beds with ridges about 40 feet apart having slopes of about 20 feet on either side with an inclination (according to the ground) from 1:50 to 1:150 or even more, if the ground is very impervious. The ridges have distributing channels so formed that the sewage flows over them, down the slope of the plot or field to the furrow in a uniform layer or film and any which is not absorbed passes to a lower plot."

"The catch water system is used more for very sidelong and irregular ground. A carrier is laid to command the area treated and the sewage overflows from it at any point by temporarily stopping up the carrier. It then passes to a lower level, where a catch water gutter, made to the contour of the land, passes it over a still lower part of the area. Main carriers vary in size but are generally about 1 to 2

foot wide and about 6 to 10 inches deep. The fall should be about 1 : 500 or 1 : 600."

The principles of irrigation will govern the arrangement and operation of the field and should not be difficult of solution by the ordinary individual.

A good tile underdrainage system will help in getting good results. These drains should be laid 5 or 6 feet deep if possible so as to afford a depth of dry surface to take the sewage. Well managed and operated, the sewage farm does not cause a nuisance and the Royal Commission of London came to the conclusion that, "there is no convincing proof that they cause direct or wide spread injury to health." This method probably gives the best purified effluent of any of the present day methods of treating sewage.

Sub Irrigation.

Sub Irrigation is very much like surface irrigation and differs from it, mainly in the fact that the sewage is distributed over the ground, by a system of tile piping laid with open joints from about 10 to 18 inches below the surface. The sewage runs out through these pipes and gradually filters away into the surrounding soil. If carefully laid so as to get good distribution of flow, this system has the advantage over surface irrigation for small plants in that it requires less labor to keep it in operation. Sub irrigation systems have been said to have been in service for as much as eleven years without cleaning, but ordinarily a person can count on having to dig the tile up and clean them about once in three years.

The distribution pipes should be laid as close to the surface as practicable because the most active bacterial action is in the first few inches of soil surface into which the air penetrates with the greatest ease. For the same reason, the flow should not be so great or so

continuous as to keep the ground saturated and the ground should be thoroughly drained. A system filled intermittently by a flush tank has the advantage of giving a sort of "breathing" effect to the ground which seems beneficial.

If no natural system of underdrainage exists or if it is imperfect, a good system of deep laid drain tile is necessary.

If the soil is sandy or loamy, this system works very well, but if the soil is of a dense impervious nature, some additional preparation of the bed to receive the sewage must be made. One of the plates in the back of this thesis shows a method that is sometimes used to increase the absorbing surface. If the soil is a clay and absorbs practically none at all, an outlet should be provided in which case the system acts almost as a contact bed. For these installations in dense clay, a ventilation pipe should be provided to get the air to the bottom of the stone bed. It is not believed by the writer that these air ducts should be more than one hundred feet long to get a good circulation of air through the pipes.

Sub irrigation is often used by laying the pipes in the front yard or under the garden. Advantage is thus taken of whatever manurial value the sewage may have and at the same time the sewage may be disposed of by a system that is completely hidden.

Sub irrigation methods have not proven very satisfactory without a preliminary treatment in the sewage tank or roughing filter. It is doubtful whether they should ever be used without such treatment. Without it, the pipes soon clog up and the deposit of solid organic matter in the pipes soon develops an anaerobic condition which on account of the gases produced shut out the air supply and so prevent the true oxidation of the sewage. On the whole, however, subsurface irrigation seems to be very satisfactory for small installations in which case

the trouble with the distribution is not great.

Intermittent Downward Filtration.

Intermittent downward filtration consists of a sand bed with a thorough underdrainage system, upon the surface of which the sewage is run in large doses after which the water is allowed to drain away and the bed allowed to rest for a time. It differs from the surface irrigation methods in that it handles much larger quantities for the same area and that no attempt is made to raise crops thereon. Sand beds already in place can be used, in which case the intermittent downward filtration bed affords a cheap method for treatment, provided of course the land itself is not too expensive. In cold climates, the surface of the filter should be turned up in ridges so that a layer of ice will form between ridges beneath which the warm sewage will flow. Little trouble has been experienced by this method in places as far north as New York and New England. The sewage hardly ever has a temperature below 40° Fah., so that the sewage after standing a few moments will melt through the sand that has been frozen during the period of rest. Of course the effluent is not as good as in the summer time, but even under these conditions the filters are likely to give better purification than either of the following types. From 75% to 97% of the organic matter is removed and from 77% to 99.9% of the bacteria are taken out. The chief objection to the method is the large filter area required, the high cost of frequent cleaning and the loss of head required to force the water through the clogged surface just prior to cleaning. The beds should be made in several parts which are covered with sewage in turn. Three beds operated in rotation makes a very good arrangement. Flush tanks may be used to flood the beds in succession but a man can change by hand the bed in use if the available head is limited and it can be made some ones business to look after it.

Rates in gallons per acre per day ranging from 250000to 400000 gallons have been found practicable on beds of carefully screened material and the experiment station at Lawrence has filtered at the rate of 300000 gallons per acre per day for three years through such selected material. Prof. Leonard P. Kinnecutt expresses the opinion that with natural sands from 50000 to 75000 gallons of domestic sewage can be purified each day. This matter will be further discussed under the design for small institutions.

Contact Beds.

Contact Beds are similar to the sand beds described above, but are composed of larger material and are used at higher rates. The material generally used is coke, broken stone, brick or slag, and gravel carefully screened to sizes (depending on the quality of the sewage) ranging from pea size up to two inches or more. The method of operation is somewhat different from the previously described filter in that the sewage is flushed on rather rapidly, allowed to stand in contact with the filtering material and then rapidly emptied out after which the filter is allowed to stand empty somewhat longer than it stood full. The time required to complete this cycle of events varies with different plants, but the following seems a good schedule:

1 hour filling,

2 hours standing full,

1 hour emptying,

4 to 8 hours standing empty.

There is undoubtedly both aerobic and anaerobic action within the contact filter, but it is the aerobic action which is by far the most important. The anaerobic action takes place mostly during the time the filter is standing full. The aerobic action is most active while the filter stands empty. During the period of standing full, the sus-

pended matter settles and is caught on the surface of the filtering material by the gelatinous bacterial coating which grows there. Some dissolved matter is also acted upon. Emptying the filter draws the air down into it and the aerobes quickly oxidize the organic matter. The beds should be filled from the top and be drawn from the bottom so as to give nearly equal contact to the sewage which first comes on the bed and that which comes on last. This also deposits the heavier sediment where it is not only more easily oxidized, but also cleaned off if too great to be handled by the filter.

Better results and higher rates can be used if two beds are used in series,- one following the other. In this case, finer material is used for the second contact. The first contact may be expected to give about 60% purification of the organic matter while the second contact may be made to give almost any degree of purification, depending upon the rate at which it is worked. Three contacts are also used to advantage under certain conditions. Contact filters may be used at rates about ten times that of intermittent downward filtration.

Sprinkling Filters.

Sprinkling filters are the most rapid in their purification of sewage; i.e. they use the highest rates, and often cost less than any of the last three named filters. They consist of very coarse material, ranging from 1 inch to 10 inches in diameter, laid up loosely and very thoroughly underdrained and aerated. In England, Mr. Stoddart often builds sprinkling filters on the surface of the ground, building them up without retaining walls by placing the largest stones or cinders around the outside and filling in between with smaller material. Very good circulation of air may thus be obtained because the wind can blow right through the pile. The sewage should be applied as a rain or as a spray over the top of the filter so that it will run over the surfac-

es of the clinkers or stones in a thin film and not completely fill the voids. The sewage is applied continuously except for rests at long intervals. The gelatinous bacterial coat which forms on the surfaces of the filtering material is very effective in changing the sewage to stable forms. Since it is this bacterial coat which is in contact with, and does the work of purifying the sewage, it is very important that this surface be as large as possible. It is probably for this reason that coke seems to give the best results of the coarse materials in common use in the sprinkling filter. Another important matter to be considered is the fact that small grained material does not drain as well nor does it get as good ventilation as coarse material. Fine grained material affords a greater superficial area upon which bacteria may grow, but the interstices of the material are more likely to stay full of water and so exclude the air. Intermittent operation obviates this difficulty but reduces the amount of sewage that can be treated on the same area. Mr. Rudolph Herring believes that it is this additional bacterial surface that gives the better purification in the case of intermittent sand filters. To get as large a superficial area, therefore, without reducing the size of the voids to any great extent, a rough irregular grain is to be preferred to a smooth surface. Smooth gravel will therefore not be as good as broken stone.

To get a good circulation of air, Mr. Rudolph Herring suggests that hoods be put on ventilation pipes connecting with the underdrainage system, which being turned into the wind by vanes would conduct the air to the bottom of the filter. Where the steepness of the country permits, it would be advisable to build the filter above ground as Mr. Stoddart does, making the sides of the larger stones, or for the sake of appearance and substantial construction, making them of hollow building block with the openings turned out, or of open brick

or stone work. The general construction would of course be the same except for the side walls.

The time of contact with the bacterial coat being very short(only a few minutes) it is important that the sewage be distributed over the surface of the filter in an even steady rain or spray, not in a sheet of water which would wash through and receive very little purification. There are several devices used to give this distribution which very somewhat in efficiency.

The Candy Sprinkler is constructed on the principle of the lawn sprinkler with the revolving arm. The filters are made round and the arm is pivoted at the center. The sewage feeds in at the center and out through the hollow arm. The perforations are made on one side of the arm and the sewage as it leaves the holes gives a backward motion to the arm which causes it to revolve around the bed.

The Feddian Rotary Distributor is constructed on the principle of an elongated water wheel. The sewage falls into the wheel at one end and the revolution of the wheel causes it to rotate around the bed, spilling the sewage in a thin sheet as it goes.

The trouble with both these distributors is, that they are likely to get out of order. The Stoddart Distributor is a stationary distributor made of galvanized iron which is crimped into triangular troughs and ridges. The sewage is fed in at one end of the troughs and fills up to the top of the ridges. Triangular holes are cut in the top of these ridges and the sewage flows out through these ridges, down over the sides and trickles off of nail points soldered on the bottom of the troughs. This gives a continuous rain over the whole filter when properly leveled and cleaned, but there is usually considerable trouble experienced in this respect. The holes become clogged and the supports settled so that some holes may not flow at all while others supply too

much sewage to the part of the bed under them.

A nozzle spray is the best distribution yet obtained, but requires about five or seven feet head to operate. It also requires constant watching and is therefore rarely applicable to the small plants under consideration .

A distributor design by the writer, which is believed to be well adapted to plants for dwelling houses is described under design.

The rates which may be used depend on the distribution. With sprinkling nozzles, the Columbus Experiment Station used rates ranging from .39 to 5 .27 million gallons per acre per day and they recommended for Columbus the use of two million gallons per acre per day.

The effluent is still turbid from these filters, but it is non putrescible. The bacterial efficiency is about 90%.

DESIGN

Quantity of Sewage to be Provided for.

In nearly all text books on sewage the quantity of sewage is taken as equal to the water consumption. This is very nearly correct in the case of the city at large, but for individual dwelling houses and institutions the average water consumption per capita for the whole city must not be taken. For instance, the average water consumption for Urbana and Champaign is given as 45 gallons per capita per day. Meter readings on several houses with inhabitants varying from 2 to 17 per house, show rates varying from 33 down to as low as 18 gallons per capita per day,- averaging about 22 or 23 gallons per capita per day. This shows that the railroad shops, laundries, etc., and leakage of water mains, must make up a large part of the water consumption in these two cities. A careful study should therefore be made to determine the amount of water consumed by the inmates of the house for which the disposal plant is to be built. Of course the size of plant is not altogether dependent upon the water consumption, but is also dependent upon the number of inhabitants contributing sewage. However in these small plants the size demanded is largely dependent on the quantity of water to be taken care of. Another thing to be considered is the fact that the greater part of this water comes, at high rates during the day, while very little sewage comes to the plant during the night. Also for small families the calculated size of the parts of the system may be so small as to be hard to work in. The design will be made for ten people but the same size would be used for smaller families.

Estimate of Cost.

The estimate of cost as given below is of course very general. Costs of both material and labor vary a great deal in different parts of the country. Besides this, very often the property owner can put in the plant himself and cut the expenditure for labor to almost nothing. The following estimates are however believed to be representative and liberal enough to cover the actual cost.

The following data was used in making estimates:

For small tanks, 7 brick will lay 1 sq. ft. of 4 in. wall;

" larger " 15 " " " 1 " " " 8 " "

4 sacks of cement equal 1 barrel;

7 1/2 gallons of water equal 1 cu. ft.

The following data is taken from Kidders Pocket Book:

To lay 1 000 brick with 1:3 mortar requires,

1 1/2 bbls. cement,

5/8 cu. yds. sand (1/2 load)

For plastering (walls and floor)

Plastering 1/4 inch thick 1:1 mortar requires,

1/2 bbl. cement for every 75 to 80 sq. ft. surface;

1/4 cu. yd. sand " " " " " " " "

(Extra cement will be allowed for neat washing inside)

A good mason with helper will lay 60 face brick per hour or 150 to 175 common brick on straight wall. An ordinary country mason lays about 120 brick per hour. For this small job work, we will assume he lays 100 brick per hour and count only full half days. A mason will count any fraction of a day as the next 1/2 day.

Masons wages average about $ .60 per hour, 8 hours per day;

" helpers " " .25 " "

Common labor " " 2.00 " day

Ditching including laying and backfilling 2 cents per running ft. for all ditches under 3 ft. and 4 cents per running ft. for deeper ditches. Prices of materials are taken from catalogues and local sources. Excavation is assumed to be done by common labor at day prices.

Lumber is taken at $35 per M ft. B. M.

Brick " " " 8 " M "

Design will be made for the two following cases:

Dwelling House:

1 0 people in house using

30 gallons per capita per day.

No rain water admitted

(Fixtures,- bath, wash basin, closet, kitchen sink, etc.)

Small Institution.

75 people contributing,

50 gallons per capita per day.

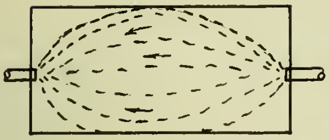
No rain water admitted.

SEWAGE TANK.

Dwelling Houses.

On account of the irregular and sudden discharges into the tank, the hours capacity will be taken somewhat larger than is usual with city plants. We will assume 18 hours flow of sewage at the average daily rate.

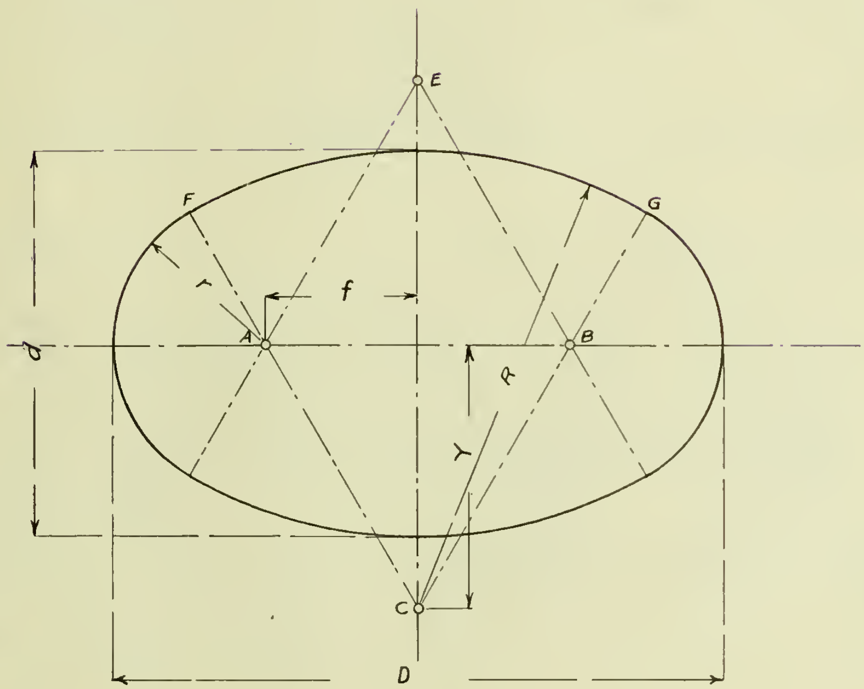
Theoretically Best Design.



In the accompanying sketch the form the flow is apt to take in a rectangular tank is shown by the dotted lines. The corners of the tank are shown to be of very little value as far as adding to the effective capacity of the tank is concerned. There is also the added disadvantage of having these corners fill up with comparatively stagnant sewage. This stagnant sewage becomes overtreated and produces foul odors and liquids which are not at all desirable.

The ellipse conforms very closely to the form the flow takes and it is not believed to be much more difficult to construct than the octagonal form shown later.

The Construction of the Ellipse by Circular Arcs.



Let D --the major diameter

" d -- " minor "

Assume d --2/3 D

Then f --2/3 (D-d) equals .222D

Erect equilateral triangles A B C and A B E so that

A B = AC = C B = AE = EB = .444D

Then Y = 1.73 f-- .385D

R = Y plus d/2 -- .718D

r = Rminus 2f .273D

To lay out the ellipse follow this method.

Lay out the major and minor diameter perpendicular to each other at the middle points. Measure f along major diameter on both sides of the center O and locate A and B. Measure Y along the minor diameter on both sides of the center O and locate C and E. Take radius CE equal to R and draw arc FG. The points F and G are located by the radii which pass through the points A and B respectively. With a radius AF equal to r draw the ends of the ellipse.

The other half of the ellipse is exactly the same and drawn in the same way.

With a string and a few stakes driven in the ground for centers, the outline of the tank can be scratched in the earth. It is not necessary that the tank conform exactly to this form, but if the hole is marked out on the ground before it is dug, it will be near enough for all practical purposes.

These dimensions are inside dimensions so that the brick work must come outside of the ellipse.

Size Required.

Assume 10 people using

30 gallons per capita per day

Capacity 18 hours flow of sewage

Total daily flow 10 x 30 equals 300 gallons

Capacity of tank 18/24 x 300 equals 225 gallons

" " " 225/7.5 equals 30 cu. ft.

Assume tank has 3 feet of water in it.

Area of tank (required) equals 30/3 equals 10 sq. ft.

It will be assumed that the equation for the area of a true ellipse is correct.

Area equals $\frac{\pi Dd}{4}$ equals $\frac{3.14\ Dd}{4}$

Since d equals 2/3 D

Area equals .524 D^2

Therefore D equals $\sqrt{\frac{A}{.524}}$

Substituting 10 for A and solving

D equals			4.36	ft. equals	4 ft.	4 in.	
d "	2/3 D	equals	2.91	" "	2 "	11 "	
f "	.222D	"	.97	" "		11 5/8 in.	
Y "	.385 D	"	1.68	" "	1 "	6 3/4 "	
R "	.718 D	"	3.125	" "	3 "	1 1/2 "	
r "	.273 D	"	1.185	" "	1 "	2 1/4 "	

Other sizes can be calculated by changing the value of A in the formula for D and then substituting this new value for D in the other equations.

A mason with ordinary intelligence should be able to construct this tank without very much trouble.

Construction.

It is believed that with the detailed drawings herein shown little need be said regarding construction. The following points should be observed:

The bottom of the tank is dished slightly for cleaning purposes.

The baffle wall has the upper and lower thirds laid in cement while the middle third is laid up in a very loose, open construction without cement so that the sewage can pass through it. The inlet and outlet should be submerged as shown, the inlet to prevent direct flow across the tank and the outlet to prevent the scum from the top of the sewage passing out through the tile.

The top may be arched to the circular man hole with cast iron cover or it may be made as the octagonal cover is constructed,- of wood. if a cast iron cover is used, it should be perforated to give ventilation to the tank.

Estimate of Brick Required.

The circumference of the ellipse may be taken from the approximate formula.

Length equals $\pi\sqrt{\frac{D \text{ plus } d}{2}}$ equals $3.14\sqrt{\frac{O \text{ plus } d}{2}}$

D equals the major diameter equals 4.33 ft.

d " " minor " " 2.91 ft.

Therefore Length equals 11.6 ft.

Surface Area of side Walls equals circumference times height wall.

Height of wall approximately 5 1/2 feet

Area of Floor equals $\frac{\pi \text{ x } D \text{ x } d}{4}$

equals 10 sq. ft.

Surface Area equals 11.6x5.5 equals 63.6 sq. ft.

For small tanks the length of the baffle wall may be taken as equal to the following:

Length of baffle wall equals 1 1/4 $\frac{d^2}{D}$

" 2.5 ft.

Area of baffle wall 2.5 x 3.5 equals 9 sq. ft.

Total Brick Surface equals 63.6 plus 10 plus 9 equals 82.6 sq. ft.

Total Plastered Surface equals 63.6 plus 10 equals 73.6 sq. ft.

It is considered that 4 inch walls are heavy enough for these small tanks. Cisterns are often built of considerable size with walls only 2 1/2 inches thick. The soil must be pretty firm however to be safely built with walls as thin as this.

Number of brick required equals 82.6 x 7 equals 580

Cost of Tank.

2 cu. yds. excavation (1/2 day)	$ 1.00
580 brick	4.60
7 sacks cement at $2.25 per bbl.	3.95
5/8 cu. yd. sand at $1 per yd.	.65
1 mason, 1 day	4.80
1 " helper, 1 day	2.00
2 elbows 4" pipe at 20 cents	.40
1 cast iron cap and cover	10.00
Total	$27.40

Octagonal Tank.

The octagonal tank approaches in shape the ellipse and is nearly as satisfactory. Use the same capacity as for the elliptical tank. The calculations of the size of tank for other capacities is conducted in much the same way as for the elliptical tank. The figures are simple and require no explanation here.

A wooden cover is shown in the drawing, but a concrete or stone cover could be used.

Cost of Octagonal Tank.

2 cu. yds. excavation (1/2 day)		$1.00
550 brick		4.40
6 sacks cement	@ $2.25 per bbl.	3.38
5/8 cu. yd. sand		.65
2 elbows 4" pipe	@ 20 cents	.40
1 mason, 1 day		4.80
1 " helper, 1 day		2.00
1 cast iron cap and cover		10.00
27 board feet lumber @ $35		.95
	Total	$27.58

Other Designs.

The drawing on page 63 shows a design for a "septic tank" as designed by Mr. John W. Alvord. It is very cheaply constructed and when a permanent tank is not desired, will probably work satisfactorily, especially where its capacity approaches the desirable capacity. Other drawings are shown of tanks designed by other engineers. These need not be explained.

SMALL INSTITUTION.

75 people consuming

50 gallons per capita per day with capacity

12 hours flow of sewage.

Total daily flow equals 75 x 50 equals 3750 gallons.

Capacity of tank equals 12/24 x 3750 equals 1875 gallons.

" 1875/7.5 " 250 cu. ft.

Assume depth of sewage equals 5 feet

Required Area equals 250/5 equals 50 sq. ft.

The octagonal shape will be used.

The dimensions required to give this area, assuming the greatest inside width as 5 feet and the width at intake and outlet as 1 foot, are shown on the drawing.

An extra baffle of 2 inch plank is shown at the inlet. This will give somewhat better distribution of flow over the tank than if we simply turned the sewage down by means of an elbow.

If the spaces between the brick in the middle third of the brick baffle wall are made smaller at the center and increasing in size as they approach the outside walls, a better distribution of flow will be obtained. A four inch sewer is shown but larger ones may be used just as well so far as the tank is concerned, provided of course the quantity of flow per day remains the same. If the tank can be placed lower down than shown an arched brick top with cast iron cap and cover might be used instead of the wooden top.

Quantities.

Brick in side walls	184 sq. ft. x 15	equals	2760	brick
" " floor	49.5 sq. ft. x 7	"	346	"
" " baffle	19.25 sq. ft. x 7	"	135	"
		Total	3241	"

Plastering equals 184 plus 49.5 equals 234 sq. ft.

Cost.

3250 brick		$26.00
27 sacks cement	@ $2.25	15.20
2 7/8 cu . yds. sand	@$1 per yd.	2.90
1 joint 4" sewer pipe	@ 6 1/2 cents (2 ft. length)	.13
1 elbow 4 " " "	@ 20 cents	.20
103 board feet lumber	@ $35	3.60
18 cu. yds. excavation (3 days)		6.00
1 mason, 4 days		19.20
1 helper, 4 days		8.00
	Total cost tank	$81.30

THE STRAINER

The strainer as here used is merely to catch the sediment and black precipitate which may be carried out of the sewage tank. It is believed that by using this strainer much trouble from the clogging of subirrigation drains and the surface of sprinkling filters will be prevented. The strainer is designed so as to be easily cleaned and is to be used at high rates. The rate used is 50 gallons per day per sq. ft. of surface.

Area required for dwelling houses equals 300/50 equals 6 sq. ft.

Construction.

12" x 12" x 3" hollow building block is used to cover the floor so as to furnish a good drainage system underneath the gravel. A shelf 1 1/2 inches wide is left on the side next the outlet so that the last row of tile may be made to rest on this shelf and the edge of the next to the last row of tile as shown in the detail drawing (page 64). This furnishes a conduit across the ends of the hollow tile on the floor, so as to give drainage to the outlet. If possible to get them the tile should be perforated on the top side as shown. Pea sized

gravel is recommended for the filtering material. It should be well screened so as to contain no fine material. If this size clogs up too fast, use a larger size of gravel. At least 2 inches of sewage should stand over the top of the gravel. In order to secure this, the invert of the outlet branch of the Tee should be carried up this far. The inlet may be at any elevation above this level of sewage. The Tee should also be carried up to the surface of the ground and be covered with a cowl or grating so as to serve as a ventilator.

Cost.

1 1/4 cu. yds. excavation		$1.00
315 brick		2.52
6-12" x 12" x 3" perforated hollow block	@ 10¢	.60
1 elbow 4"	@ 20¢	.20
1 Tee 4"	@ 25¢	.25
2 joints sewer pipe 4"	@ 6 1/2¢	.13
3 sack cement	@ $2.25 per bbl.	1.70
3/8 cu. yd. gravel	@ $1 per yd.	.25
1/3 cu. yd. screened gravel (1/4 in. size)		.25
cowl		.25
1 mason (1/2 day)		2.40
1 helper (1/2 day)		1.00
	Total	$10.55

Other Designs.

On the drawing with the "septic tank" designed by Mr. Jown W. Alvord is shown a filter which he calls an anaerobic filter. This filter serves the purpose of a strainer but is somewhat larger than the one here designed and of course is not of as substantial construction. The sewage enters the filter from the "septic tank" from below and filters up through the gravel layers and is taken off at the top. It

seems to the writer that it would be much easier to clean and be just as efficient if the sewage was made to enter at the top and filter down and be taken out as it is from the strainer here shown. (page 64)

SUB IRRIGATION

For Sandy and Loamy Soils

Mr. Alvord recommends for the design on page 63 about 1 foot of three inch tile distributor for every gallon of sewage. He says further,- "In sandy soils about 1/2 a foot per gallon of sewage flow will probably be ample. In close clay soils 2 to 4 feet of tile per gallon is probably, generally, too little".

Assuming that 1 foot per gallon is sufficient, it will require 300 feet to take care of the sewage of the dwelling house and 3750 feet for the institution. Lay the tile as close to the surface as possible, say from 10" to 18" deep. The former depth is better than the latter. Lay on a very uniform even grade of say 2 inches in 100 feet. Lay with open joints and either wrap the joints with cheese cloth or preferably lay with trough and cover as shown on page 63 . The best kind of Y's are also shown on this same page. Mr. Edward S. Philbrick says the lines of lateral distributers may be placed at intervals of 5 or 6 feet. A flush tank is desirable in the case of the dwelling house and is necessary in the case of the small institution because it makes use of the whole bed and does not overwork that part of it the sewage strikes first. The size of flush tank necessary is calculated to just fill the laterals at one flush.

Dwelling Houses.

Flush Tank

A three inch siphon will be large enough.

Area of the end of a 3" tile equals 7.09 inches equals .049 sq.ft.

Length of distribution tile 300 ft.

Cubic capacity of tile equals 300 x .049 equals 7.35 (say 10) cu.ft.

Discharging depth of siphon equals 18 inches.

Area of tank equals 10/1.5 equals 6.6 sq. ft.

Make either square or round, (estimated as 2' - 7" square and 2' - 6" deep.)

250 brick	$2.00
3 sacks cement	1.70
3/8 cu. yds. sand	.37
1 siphon	20.00
1 cap and cover	10.00
1 mason (1/2 day)	2.40
1 helper (1/2 day)	1.00
1 cu. yds. excavation	1.00
	$38.47

Cost of Flush Tank.

Distribution System

300 ft. 3" drain tile	@ 1.8 *per* ft.	$5.40
1 Y 4"	@ 25¢ " "	.25
1 elbow 3"	@ 20¢ " "	.20
Ditching, laying and backfilling	@2¢ " "	6.00
Cost of Distribution System		$12.05

Small Institution-75 people.

Number of gallons used 3750 gallons per day.

1 gal. per ft. requires 3750 linear ft. of distribution tile.

A flush tank is necessary.

Flush Tank

Area end of tile equals 7.07 sq. in. equals .049 sq. ft.

Cubic capacity of tile equals 3750 x .049 equals 184 cu. ft.

Use 3 inch siphon. Discharging depth 18 inches.

Area required equals 184/1.5 equals 123 sq. ft.

Make 10' x 12' x 3'

If the field is divided into two equal parts with two siphons placed in the same flush tank, better results will be obtained from the field and the size of the tank can be reduced one half (page 71) The siphons will automatically discharge into two parts of the field in alternate turns without any connecting device after they are once started.

Cost with one siphon (tank 12' x 10'x 3' and 8" wall)

2850 brick	$22.80
21 sacks cement	11.80
2 1/4 cu. yds. sand	2.25
1 - 3" siphon	20.00
326 board ft. (lumber for cover)	11.40
17 cu. yds. excavation	3.00
1 mason (3 days)	14.40
1 helper (3 days)	6.00
Cost with one siphon	$91.65

Cost with Two Siphons (tank 7 1/2' x 8' x 3' with 8" wall)

1932 brick	$15.50
17 sacks cement	9.60
1 3/4 cu . yds sand	1.75
2 -3" siphons	40.00
100 board ft. lumber	3.50
1 0 cu. yds. excavation	2.00
1 mason (2 1/2 days)	12.00
1 helper (2 1/2 days)	5.00
Cost with two siphons	$89.35

Cost of Distribution System

3750 ft. 3" lateral distributers	@ 1.8¢ per ft.	$67.50
3750 ft. 3" underdrains	@ 1.8¢ " ".	67.50
Elbows, Y's, etc.		10.00
Ditching, laying and backfilling, less than 3 ft.	@ 2¢	75.00
" " " " more " "	@ 4¢	150.00
Cost of Distribution System		$370.00

Above cost does not include the cost of leaders and main collectors, because they depend for their length and size on the design by which the field is laid out.

Systems of Subirrigation

Several of the drawings show different systems of laying out the field for absorption of sewage. Attention is particularily called to that shown on page 65 designed by Col. Geo. F. Waring which shows a large plant for 450 people. The field is divided into three sections which are operated separately. Only one flush tank is used and the sections in use are changed by hand by means of valves. The lower end of the leaders have a blow off valve placed near the end, so the leaders can be flushed out.

The laterals are 2 inches in diameter and are laid on contours. Underdrains, (shown dotted,) are laid across the field and are about 6 feet deep. On the side next the hill, from which the ground water comes, a blind ditch, filled with broken stone, is dug so that it intercepts this ground flow and furnishes it an outlet to the subdrains. Open ditches are used for main collectors from the field, but large tile could be used just as well. For large sized subdrainage systems, this is one of the best worked out the writer has seen.

One of the systems shown (page 62) shows the underdrains as being laid between the distribution tile and only a foot deeper. This may require more land area and is not so likely to give good underdrainage. It has the advantage of placing the underdrains closer to the surface so that it is not so difficult to find an outlet. It should also be used in modified form when the porous soil is in a very thin layer and is underlaid by an impervious clay or shale. In this case the underdrains should be placed just above the impervious stratum.

Sub Irrigation in Clay Soils.

As has been said, dense clay soils absorb water very slowly. If the clay is depended on to absorb the water in the sewage, it is necessary to furnish a large absorption area. Often this is too expensive or at times impossible. A method quite often used is one similar to that shown on pages 61 and 66 . Mr. John W. Alvord says of this system: "Where you ditch and underlay the distribution tile with gravel and further underdrains, I have been successful with as little as 1/4 of a foot of tile per gallon of sewage distributed, although this is not to be commended as good practice." As a safe practice 1/2 foot per gallon of sewage is advised.

The underdrains or air pipe should be connected by ventilators

to the atmosphere so that as much air as possible will get into the gravel (cinders or broken stone) filling.

The grades of the distribution tile and air tile are only estimated to be about the desirable slope and should be adjusted if not satisfactory. What has been said about laying with open joints in sandy soil, applies equally well here. After the top row of tile has been placed and covered with gravel, a layer of coarse sand ought to be spread over the top before covering with earth, so as to keep the earth from washing down into the stone or gravel. Some engineers use hay or straw for the same purpose, but that is not believed to be good practice because the hay will rot and form a mat of decaying matter over the top, through which air can not penetrate.

If the soil is very dense, it may be necessary to provide an outlet for the water which gathers in the ventilation pipe. To keep the sewage from rushing through the gravel and ventilation pipe too rapidly, lay the outlet drain parallel to the ventilation pipe extended as shown and fill between with gravel. Just how long this extension should be, cannot be told except by trial. Three lengths of pipe laid 2 feet from the air pipe would be a good arrangement to try. No direct connection between the distributing pipe and this outlet pipe should be allowed to form . This would be a good place to use a hood on the ventilator as Mr . Herring suggests for sprinkling filters (see page 23).

Lengths of distribution and air laterals should be very little over 100 ft.

Dwelling Houses.

300 x 1/2 equals 150 feet of distribution pipe needed.

This might be used all in one length, but probably better be made in two lengths. It is thought that for this short length of distribution pipe, no flush tank will be required.

Cost.

150 ft. 3 in. laterals	@ 1.8¢	$ 2.70
157 ft. 4 in. air pipe	@ 2¢	3.14
3 ft. 3 in. outlet pipe	@ 1.8¢	.54
8 cu. yds. gravel in place	@$1.5 per cu. yd.	12.00
157 ft. ditching, laying, etc.,	@ 2¢	3.14
2 - 4" elbows	@ 20¢	.40
2 - 3" "	@ 18¢	.36
1 - 4" Wye	@ 25¢	.25
1 - 3" "	@ 20¢	.20
2 cowls	@25¢	.50
Cost of Distribution System		$23.23

Small Institutions.

Length required equals 3750 x 1/2 equals 1875 ft.

Make in 18 lines.

A flush tank will be required.

Area end of distribution pipe equals .049 sq. ft.

Cubic capacity of laterals equals 1875 x .049 equals 92 cu. ft.

Say 100 cu. ft.

By dividing field into two equal parts, the size of tank can be made to hold 50 cu. ft., using two siphons.

Flush Tank

Use 3" siphons, discharging depth 18 inches.

Area required equals 50/1.5 equals 33.3 sq. ft.

Make 5' x 7' x 3' -(8" walls.)

1450 brick		$11.60
13 sacks cement	@ $2.25 bbl.	7.30
1 3/8 cu. yds. sand	@ $1 cu. yd.	1.38
5 cu. yds. excavation		2.00
2 -3 in. siphons		40.00
1 mason 2 days		9.60
1 helper 2 days		4.00
64 board feet lumber	@ $35 per M. B. M.	2.24
Cost Flush Tank		$78.12

Cost Distribution System.

1875 ft. 3 in. laterals	@ 1.8¢	$33.80
1947 ft. 4 in. air pipe	@ 2¢	39.00
72 ft. 3 in. outlet	@ 1.8¢	1.30
2 019 ft. ditching, laying, etc.	@ 2¢	40.38
93 cu. yds. gravel in place	@ $1.25	116.00
36 - 4" elbows	@ 20¢	7.20
36 - 3" "	@ 18 ¢	6.50
18 - 4" Wy's	@ 25¢	4.50
18 - 3" "	@ 20¢	3.60
36 cowls	@ 25¢	9.00
Cost of Distribution Pipe		$261.28
Total cost of system		$339.40

Good clean furnace cinders would do nearly as well as the gravel and might be used, if cheaper.

Other Installations.

Mr. Ashley uses a system similar to the above for the second stage of purification. One of the plates page 62 shows a similar system used by Mr. Alvord. The added depth of gravel he uses is likely beneficial, especially if the gravel is coarse, but it adds to the expense both on account of the greater depth of ditching and also on account of the greater amount of material used. Neither does a deep layer of gravel have as good air circulation.

SPRINKLING FILTERS (for dwelling houses only)

Sprinkling filters will be more desirable in certain cases because they occupy less space and are more easily cleaned than sub irrigation drains and distributers. Sometimes too, it is impossible to get land that is at all suitable for sub irrigation, for instance, on steep side hill country where it is difficult to get the distributers on a good grade. Here a sprinkling or percolating filter is especially applicable.

The Distributer.

The greatest difficulty with these filters is to get a good distribution of sewage over the surface, in the form of a rain, without having complicated apparatus. The distributer, to be successful, must be simple and must work without much care being taken of it.

Of those in use, the Stoddart style of distributer for small institutions is probably the best. However, it must be cleaned frequently to keep the holes open, it must be truly level, and it quickly rusts out. (page 67)

A distributer designed by the writer and tried with clean water in the laboratory, seems to give very good satisfaction as far as distribution is concerned. The distributer (see page 67) consists of a block of cement and sand with a flat top 6 inches in diameter. The sides slope very slightly to the edges which are rounded on about an inch radius. The lower surface is in the form of a very flat cone. Spikes are left protruding from the under side so as to form drip points. It was found in the tests performed, that these spikes should be very close together around the outer edge, thinning out towards the center. The best spacing of these nails has not been difinitely determined, but from 1 to 1 1/2 inches is believed best for the row a-

round the outside. No nails need be placed right in the center as the water that gets there will drip off any way. From the experiments conducted, it is believed that the slopes are entirely satisfactory. However, since the block tested was only 1 foot 7 inches in diameter, it might be found that other slopes would work better on larger blocks. The block was cast in sand which had been shaped to the form of the under surface. The nails were stuck into the sand, points down, and the cement mortar worked in around them. The top was fashioned with a trowel. The edges were rounded by hand. Although the edges were not very well formed, it seemed to make very little difference with the distribution. Two rods were laid in the sand across the block before the casting so as to form the supports. The shape of the block and these supporting rods are shown in the diagram. A better mould in which to cast the block could be made in clay. Cut a piece of thin board to the shape of a cross section of the block and after puddling the clay and fashioning it to nearly the correct shape, the exact form may be obtained by turning the templet or board around till the clay has taken the proper form. After the mould has been made, stick the spikes in as close to the edges as possible. Scatter other nails around the middle area of the block thinning them out as the center is approached. Place the supporting rods or pipes across the mould so the two rods are level and so they pass through the center of the disk. Thoroughly pack the cement into the mould, completely covering the nail heads. See that no large holes are left in the block. Fashion the top with a trowel or, if not expert in such work, cut another templet to the form of the top and make true as was done before in making the mould. Finish it with a trowel and allow to harden for several days before handling. (See pages 73 and 74 for results of tests for distribution with this distributer).

The General Filter Construction.

The construction of the filter is shown on page 68 . The walls need not be plastered and the only purpose of the floor is to afford a good surface to clean and to keep the dirt out of the underdrains. The floor can be constructed with brick laid flat if desired. Three ventilation pipes are used. Here again hoods to catch the wind might be used to advantage. The bottom should be sloped towards the middle drain so as to quickly collect the water which has percolated through the stone at the edges. Brick are left projecting from the walls at the proper places to catch the rods which support the distributer. A wooden top with ventilator is shown in the sketch. A concrete top could be used, but it must be removable so that the distributer can be taken out and the filter cleaned. For the same reason, the inlet pipe should not be set tight in the wall but the hole in the wall should be made large enough so the pipe can be withdrawn. The pipe should be long enough to extend back of the wall and support the protruding end, with the attached elbow. It should center the flat top of the distributer in one direction, and extend slightly over the center in the direction of the flow. The purpose of this is to center the slow flow of sewage through a large portion of the day, when the water will cling closely to the inside curve of the elbow. One inch off center is believed to be enough.

The distributer should be leveled as nearly as possible, although it seems to give fair distribution even when considerably out of level.

The filtering material should be of uniform size,-2 inch broken stone is recommended. Coke is better if it can be obtained. Gravel is not very good on account of the smoothness of its surface(see page 23) Instead of making the filter round with brick walls, a wooden box con-

struction could be used, if desired. The distributer should, however, be made round as before and the effective size of the filter should be considered round and but little larger than the distributer itself. The corners of a square filter will not materially add to the effective surface of the filter. A hollow building block could be used for outside walls to good advantage on steep slopes (see page 23).

The cost will be figured for the brick construction shown in the drawing.

Size Required.

We will assume 23 gallons per sq. ft. per day (equal to 1,000,000 gal. per acre per day.) We assume this rate because the experiments at Columbus (page 25) were under ideal conditions, well watched by experts.

Area required equals 300/23 equals 13 sq. ft.

Diameter required for distributer equals $\sqrt{4A/\pi}$ equals 4 feet.

Make filter enough larger for convenient handling of the distributer and for thorough aeration of the filtering material.

Make filter 4 ft. 6 in. diameter.

Cost.

900 brick (4" walls and floor)		$7.20
10 ft. 4" drain tile	@ 2¢	.20
24 ft. 4" sewer pipe (ventilators)	@ 6 1/4¢	1.50
1 4" Tee (sewer)	@25¢	.25
2 - 4" elbows (sewer)	@ 20¢	.40
1 - 4" cross (drain)	@ 25¢	.25
3 cowls	@ 25¢	.75
1 5 ft. length, 4" cast iron soil pipe		2.00
1 4 in. cast iron elbow		.80
2 1 in. gas pipe lengths 4' - 2" long	@ 5¢ per lb.	.70
20 d spikes		.25
1 mason 1 1/2 days		7.20
1 helper 1 1/2 days		3.00
10 sacks cement		5.63
3/4 cu. yd. sand		.75
2 1/2 cu. yds. clean 2" broken stone	@ $1.65	4.10
6 cu. yds. excavation		3.00
		$37.98

Small Institutions.

The writer endeavored to get a good design of sprinkling filter for a small institution, but was unable to get very satisfactory distribution over the large areas required, without the use of nozzle spray or some other complicated distributer. A pen picture of a simple design used in England by Mr. Stoddart is shown on page and might be adapted to use in some cases.

The filter designed for small institutions is an Intermittent Downward Filtration bed.

INTERMITTENT SAND FILTER.

Earth containing walls may be used for Intermittent Sand Filters. The surplus earth should be thrown up as a levee around the filter.

Assume rate at 100000 gal./acre/day when used with the sewage tank. (equals 2.3 gal./sq. ft./day)

Area required equals 3750/2.3 equals 1633 sq. ft.

Make 40.5 feet square, 5 feet deep with 1:1 slopes. This 40.5 ft. dimension is a mean dimension, so that the dimension at the top is 40.5 plus 5 equals 45.5ft. and at the bottom it is 40.5 -5 equals 35.5ft .

A thorough underdrainage system must be put in. Slope the bottom gently towards the main collecting drain in the center and lay 3" laterals every 8-10 feet beginning 4 - 5 feet from one side. Place 6 inches of coarse gravel or broken stone in the bottom and cover with 4 1/2 feet of good clean building sand. The sewage will be run from a flush tank onto the filter five times a day. Average time between flushings will then be 4 hours, 48 minutes.

Size flush tank 3750/5x7.5 equals 100 cu. ft.

Depth discharge 3" siphon 18 inches.

Area of flush tank equals 100/1.5 equals 6.67 sq. ft.

This happens to be the same size as the one whose cost was estimated on page 39 which see.

Distribute sewage from flush tank in wooden 4"x6" troughs 28 ft. long. Distribute from the troughs at four points as shown in drawing.

Cost.

272 cu. yds. sand in place	@ $1.50	$410.00
34 " " gravel " "	@ $1.25	42.50
70 board feet lumber		2.45
272 cu. yds. excavation,4 men, 9 days		72.00
152 ft. 3" laterals	@ 1.8¢	2.74
38 ft. 4" main collector	@ 2¢	.76
4 crosses	@ 30¢	1.20
Labor, 2 days		4.00
Cost filter alone		$535.65
Flush tank		38.47
Cost of filter and flush tank		$574.12

The cost of the sand is seen to be by far the largest item in the expense of building this filter. Where sand and gravel are found in the immediate vicinity, the cost of the filter may be cut down a half, or even more. No roof is included in the estimate. One can be used if desired.

Intermittent sand filters are very common in New York and New England where a natural sand bank or beach is used without much expense except for underdrainage and cleaning. These filters ought to have the surface raked very frequently and should be ridged in winter if exposed in cold climates (see page 70).

TOTAL COST OF PURIFICATION PLANT.

(Cost is exclusive of the cost of any sewers connecting different parts of the system because this is dependent entirely on the location of the parts.)

Dwelling Houses.

With Plain Sub Irrigation, Sandy Soils

Sewage tank	$27.50
Strainer	10.50
Distribution system, exclusive of flush tank	12.00
Total cost without flush tank	$50.00
Cost flush tank	38. 50
Total cost with Flush Tank	$88.50

With Sub Irrigation for Clay Soils (see page 66)

Sewage tank	$27.50
Strainer	10.50
Distribution System exclusive of flush tank	23.50
Total cost without flush tank	$61.50

With Percolating Filter (see page 68)

Sewage tank	$27.50
Strainer	10.50
Filter	38.50
Total cost (no flush tank needed)	$76.50

Small Institutions.

With Plain Sub Irrigation.

Sewage tank	$81.00
Distribution system	370.00
Flush tank	90.00
Total cost system	$541.00

With Sub Irrigation Clay Soils.

Sewage tank	$81.00
Distribution system	261.50
Flush tank	78.00
Cost of system	$420.50

With Intermittent Downward Filtration.

Sewage Tank	$81.00
Filter	535.50
Flush tank	38.50
Total cost system	$655.00

OTHER PLANS FOR PURIFICATION.

On page 71 is shown a design by Mr. Wm. S. MacHarefor a number of farm buildings. The design is different from any other plans shown in this thesis in that it does not use a sewage tank. The sewage enters the small chamber to the left, which on account of its small size is merely a grit chamber (see page 10). Flowing under the first curtain wall it passes over the weir into a second larger chamber. The sewage leaves this chamber by passing under the second curtain wall and over the stub wall into the siphon chamber. The two last chambers constitute the flush tank. The purpose of the second curtain wall and the stub wall is to keep the sticks and floating matter from getting into the siphon and rendering it inoperative. If a sewage tank had been used, these walls need not have been used. The two siphons empty on the two parts of the field in alternate turns. While an ingenious design, it is doubtful whether the system is as good as if a sewage tank had been used for preliminary treatment.

SYSTEM TO BE CHOSEN.

Dwelling Houses.

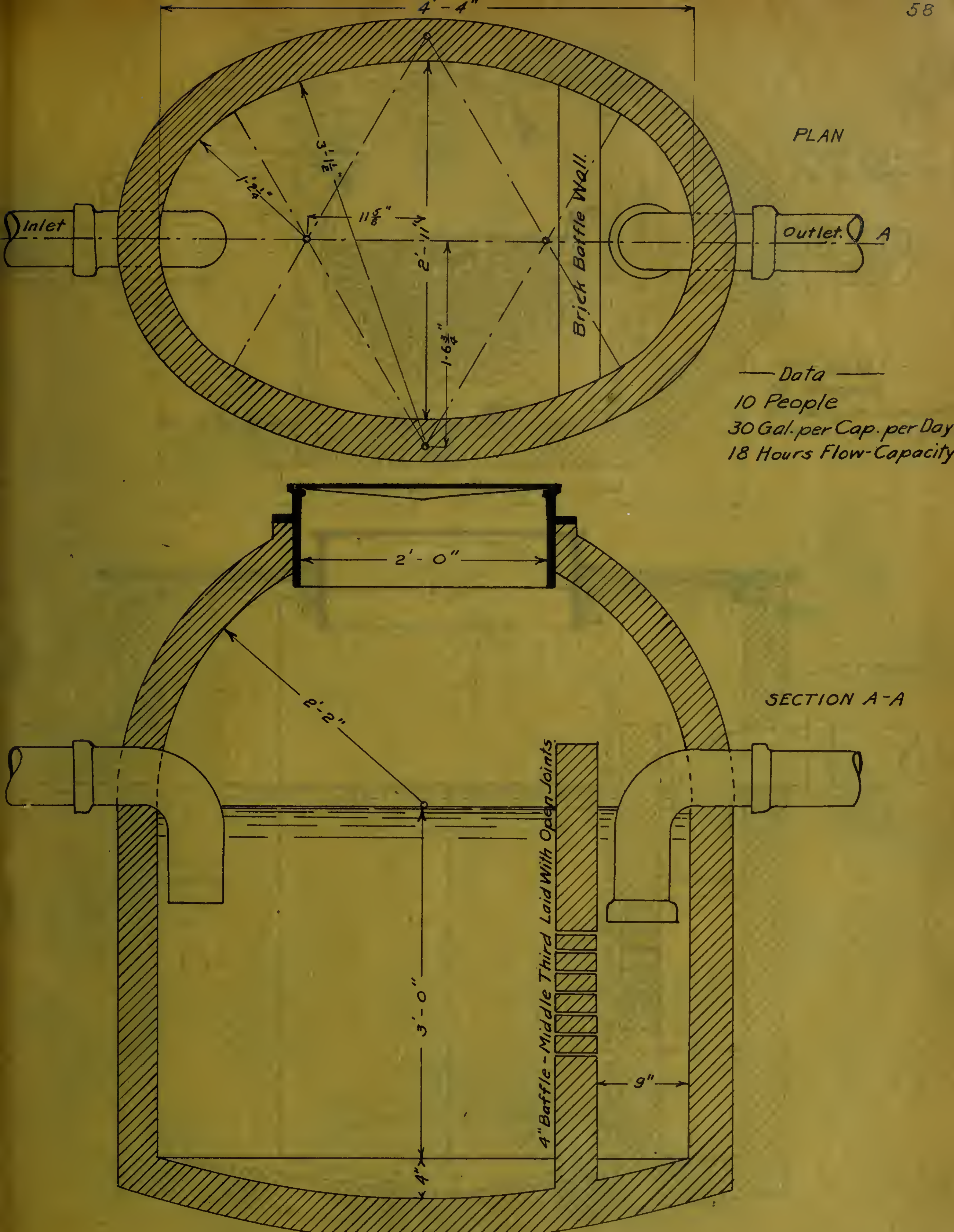
A sewage tank is considered necessary to all installations. Although the strainer is not essential, it is thought that on account of its small cost, it will save money and time in operating the other parts, because it will be so easily cleaned.

Whether a percolating filter or a subirrigation system, and if the latter, which one of the two kinds would be best to use, depends on the relative cost of materials out of which the parts are made, the porosity and obtainable area for the purification, and the topography of the land. A level country is usually best suited to irrigation methods while a bluff will furnish splendid opportunities for a percolating filter. In sandy soil, a plain subirrigation field will likely be best. In compact clay soils, where the obtainable fall is small, the gravel ditch irrigation method may be best. The particular one that should be used for any given case, is a matter of judgment, and should be determined upon, only after a careful study of the conditions.

Small Institutions

On account of its size, no strainer is designed for small institutions. It might be advisable to use a strainer with subirrigation methods, but not with the intermittent filter since the filter is so easily cleaned any way. A sewage tank is to be used as preliminary to other treatment. The price of material is very important in determining the method of secondary treatment that is best adapted to the given case. It is likely that the filter will give the least trouble, except for the regular cleaning of its surface. It is in fact usually the best method to adopt. The subirrigation method has the advantage of being mostly hidden from view. Another thing in favor of the filter

is that it can be put in by the ordinary workman, while an engineer should be employed to lay out a system of subdrains and distributers in order to get good grades and levels. This will add materially to the cost of installation and should be added to the estimated cost given above.

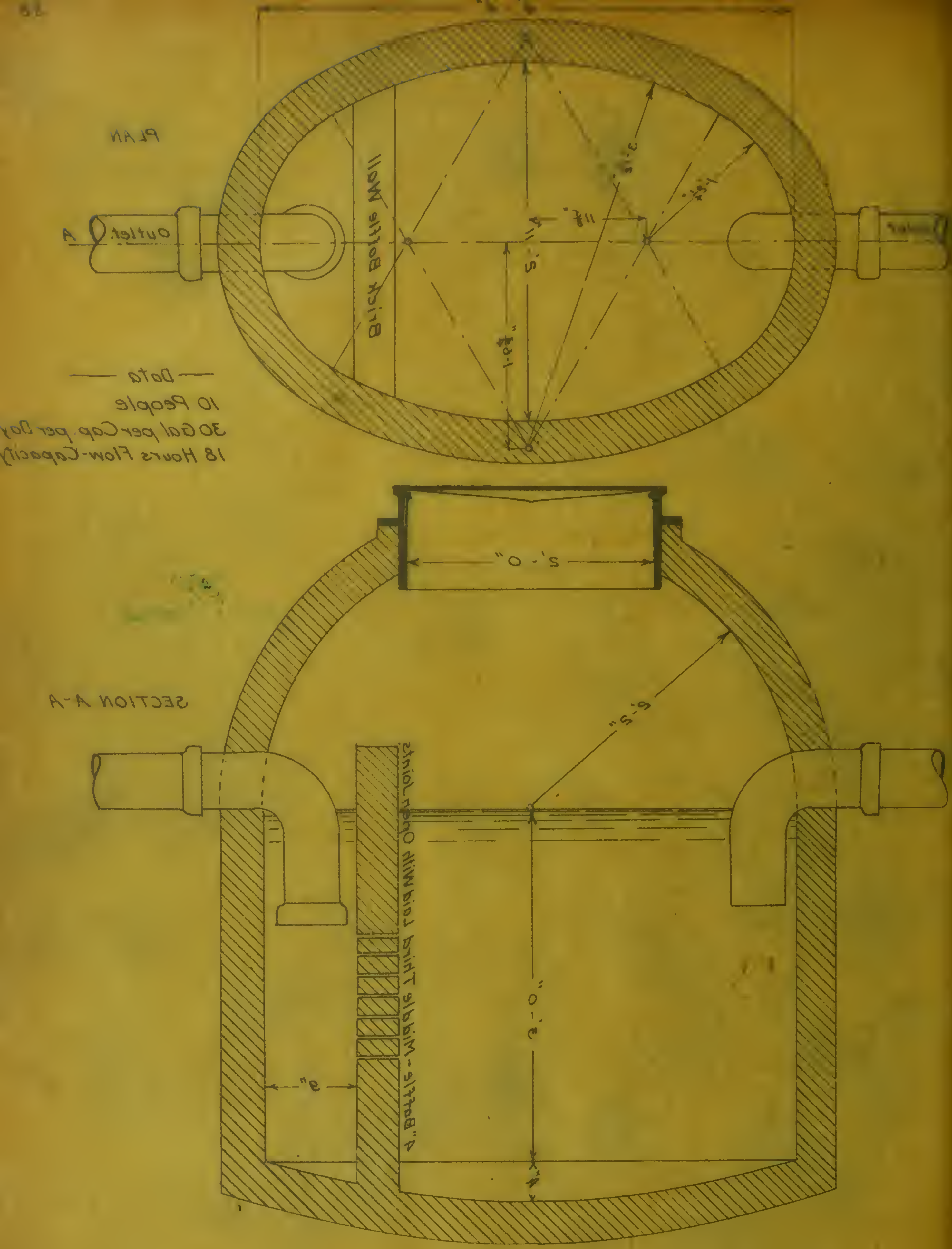


Sketch Showing

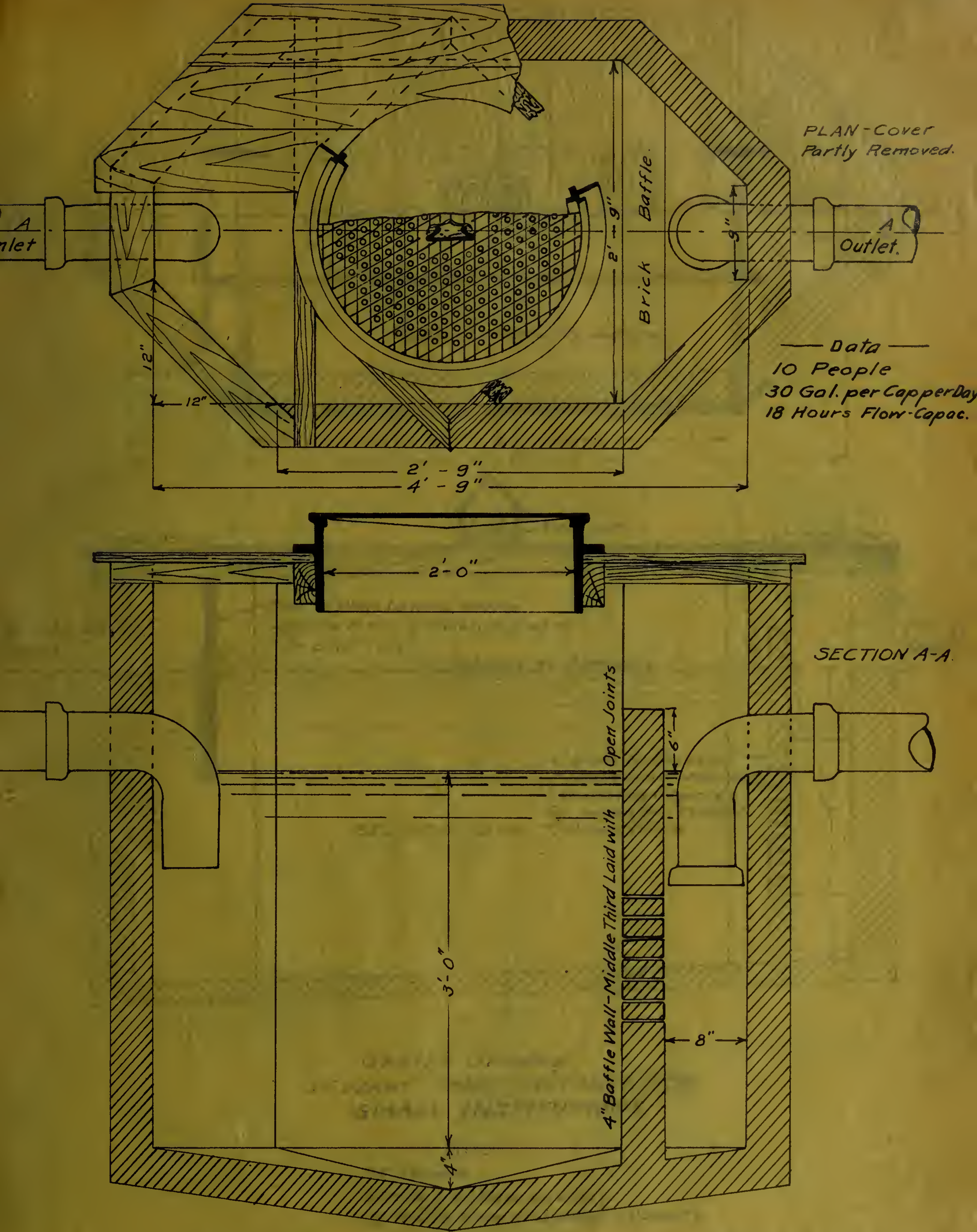
ELLIPTICAL SEWAGE TANK FOR **DWELLING HOUSES**

Scale 1" = 1'

Designer W. T. McClenahan



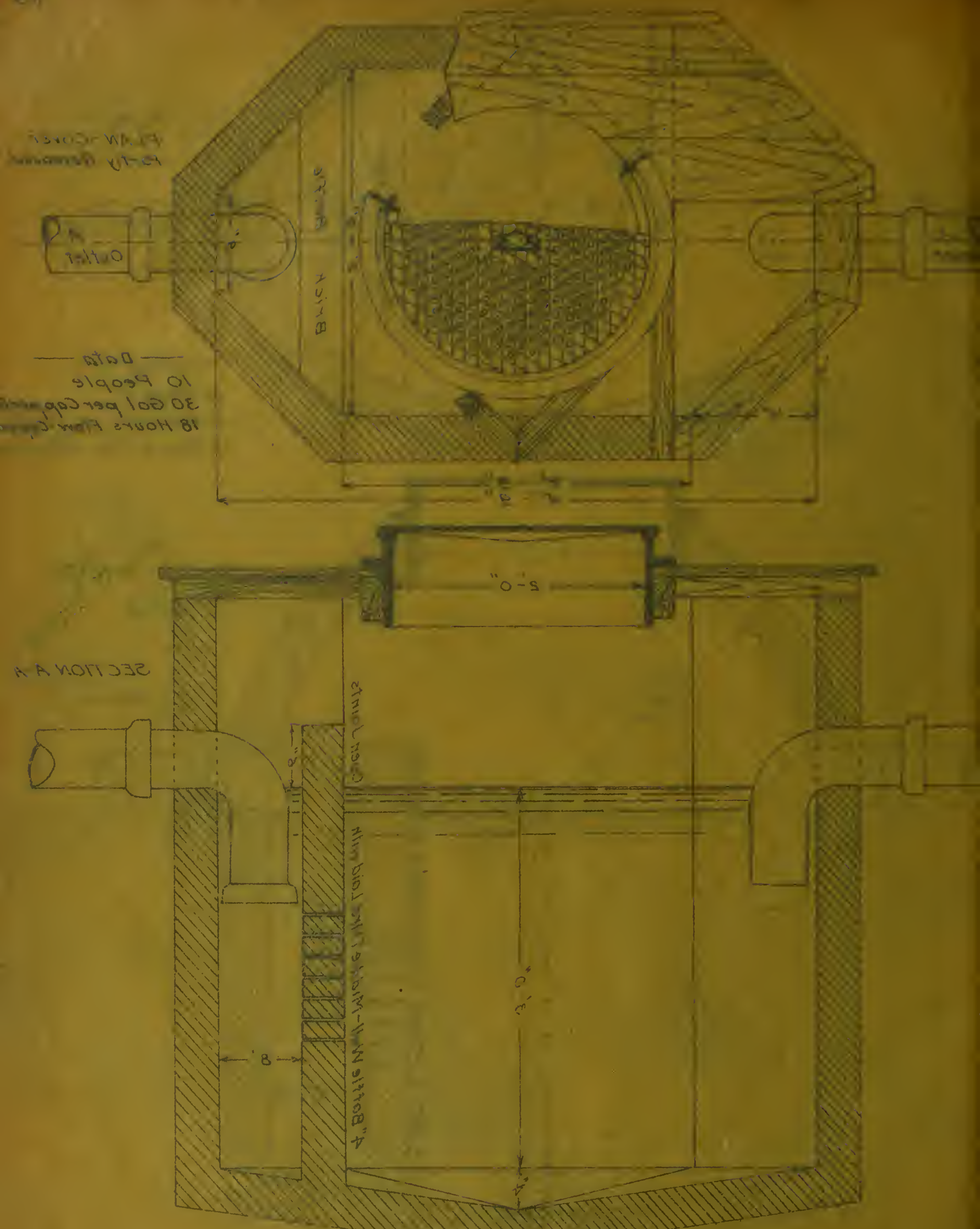
Sketch Showing
ELLIPTICAL SEWAGE TANK FOR DWELLING HOUSES
Scale 1" = 1'
Designer W T McClenahan



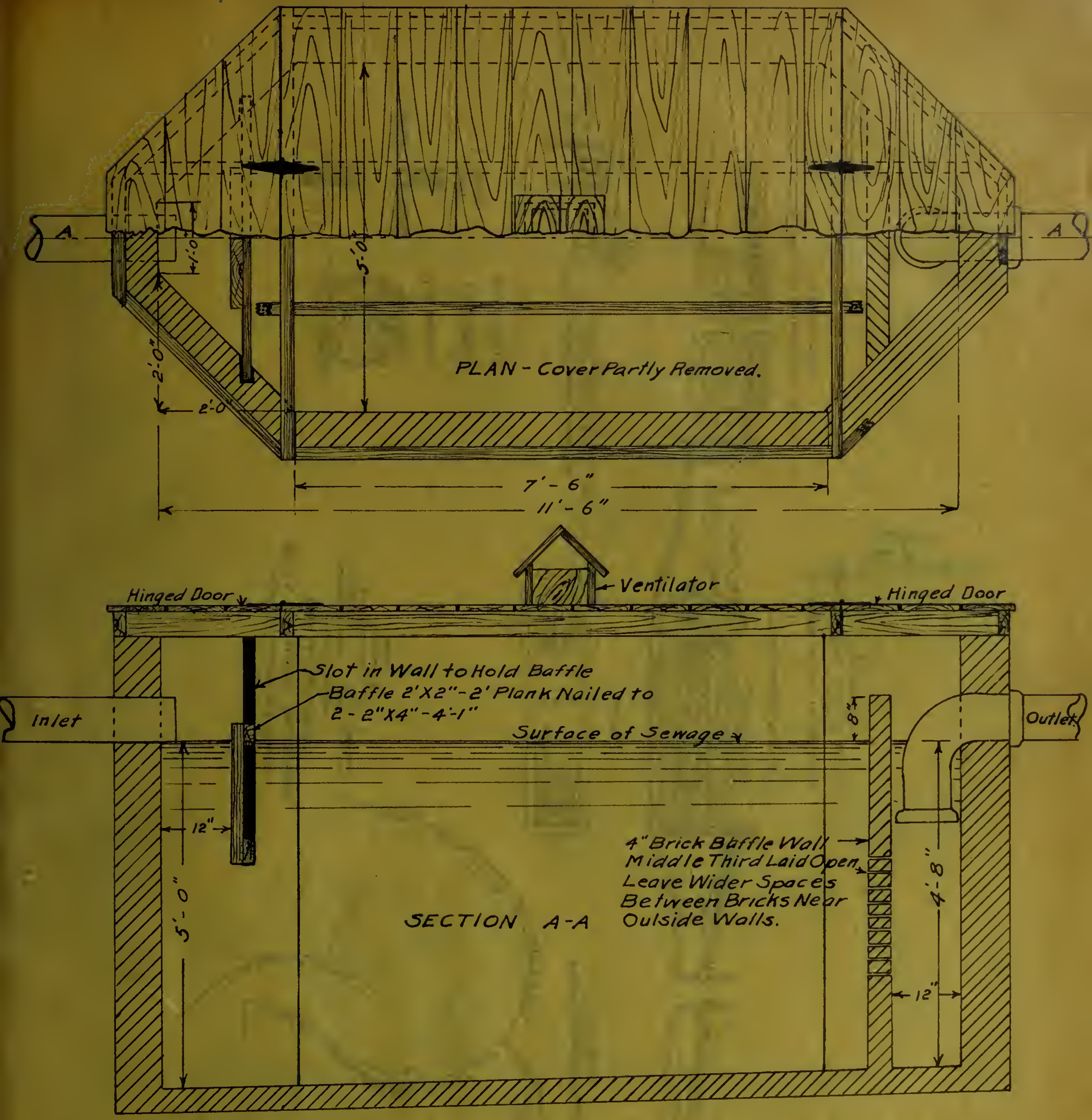
Sketch Showing
OCTAGONAL SEWAGE TANK FOR DWELLING HOUSES

Scale 1"=1'

W. T McClenahan
Designer



Sheet A Showing
OCTAGONAL SEWAGE TANK FOR DWELLING HOUSES
Designer
Scale

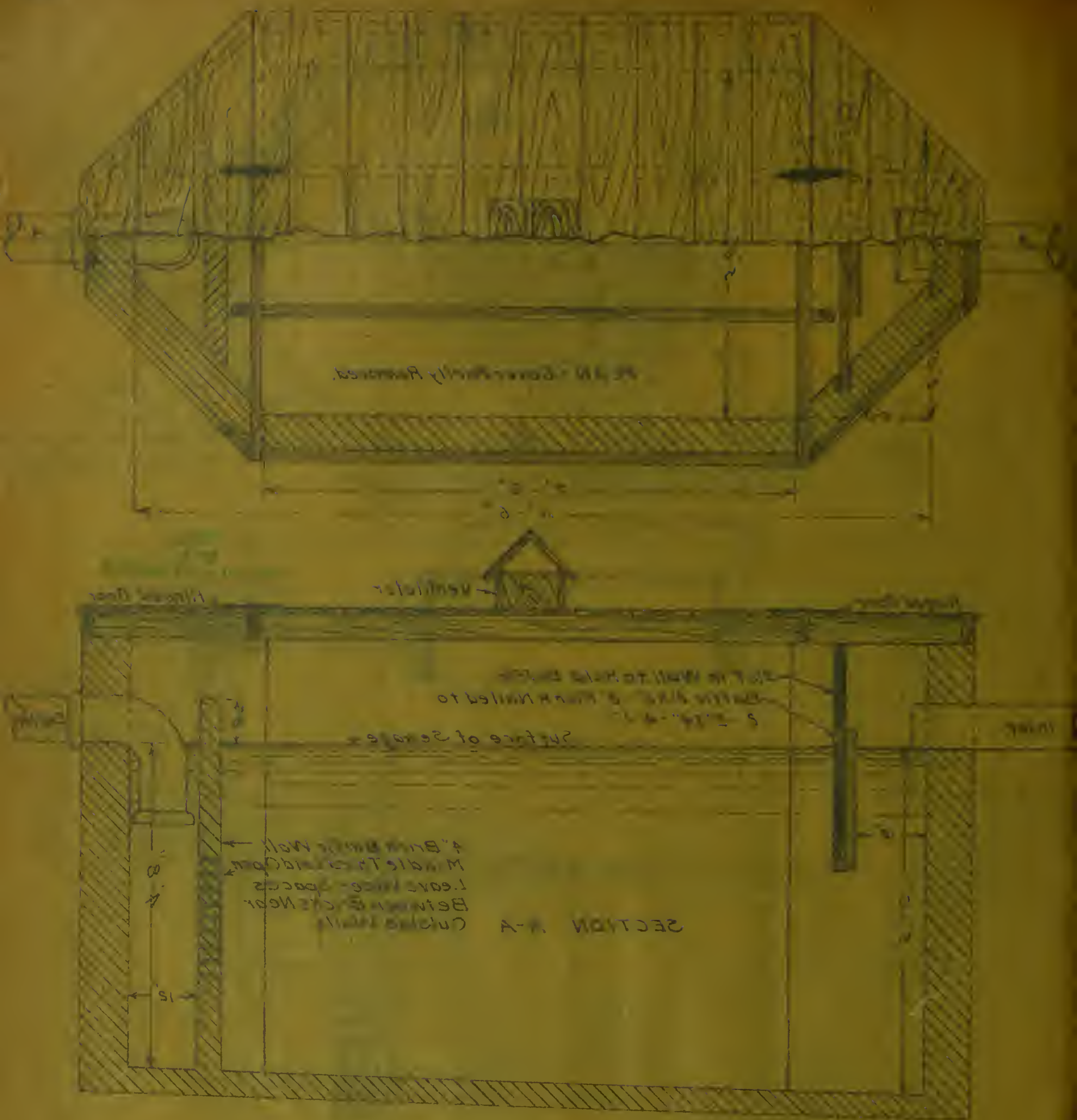


Sketch Showing
SEWAGE TANK SUITABLE FOR
SMALL INSTITUTIONS

Data
75 People
50 Gal. per. Cap. per Day.
12 Hours Flow of Sewage Capacity

Scale 1/2" = 1'

W. T. McClenahan
Designer

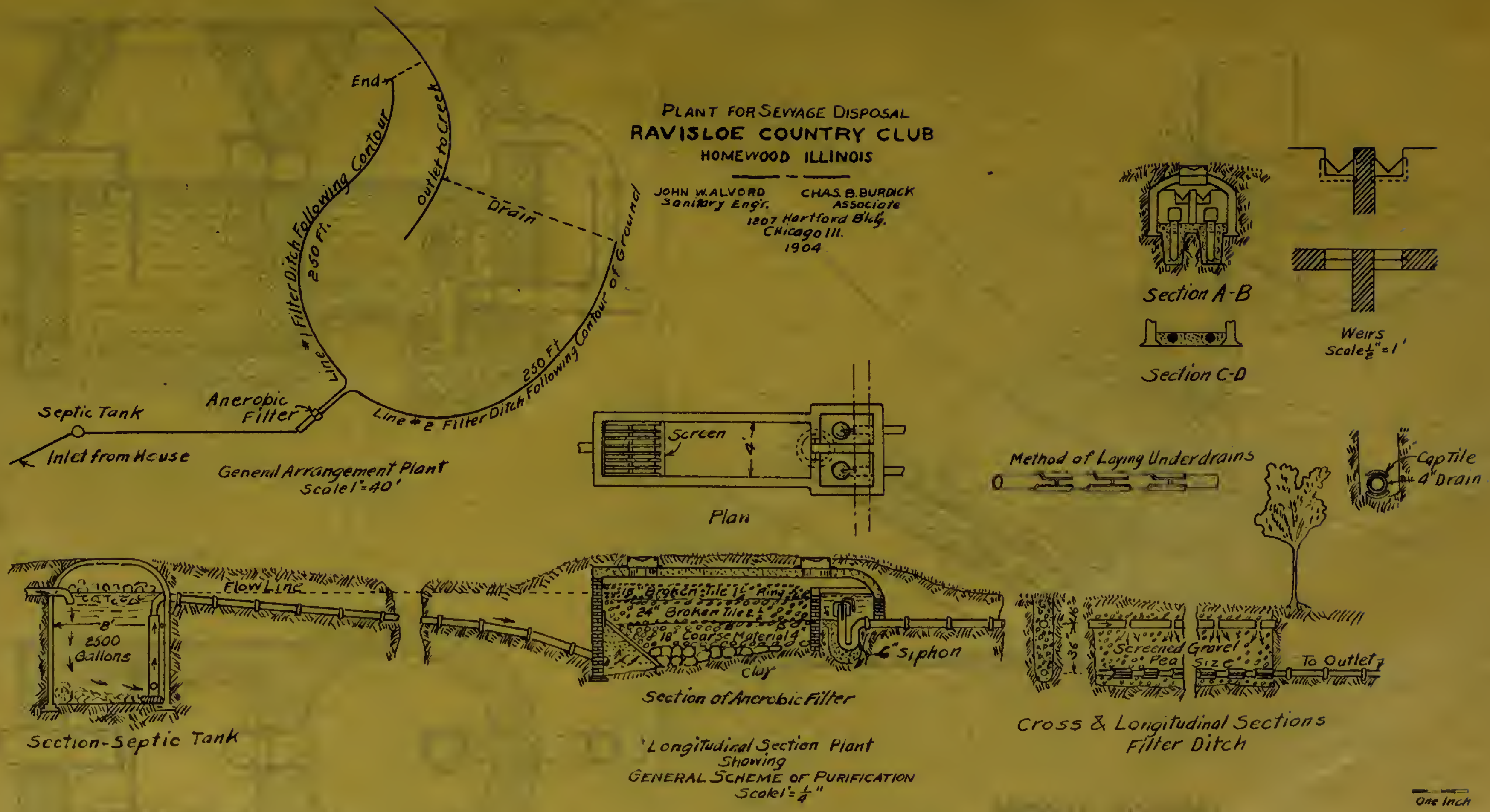


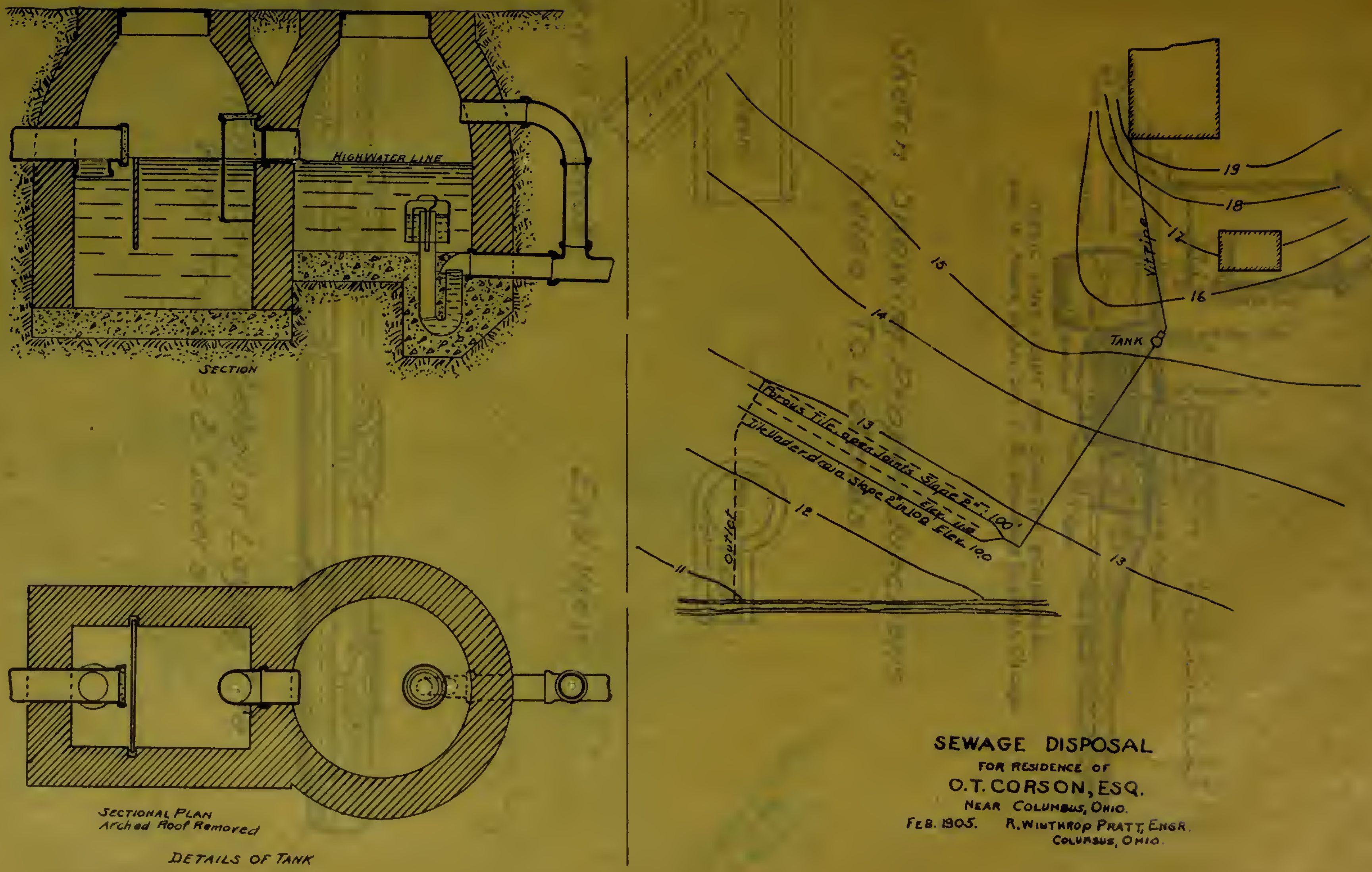
Sketch Showing
SEWAGE TANK SUITABLE FOR
SMALL INSTITUTIONS

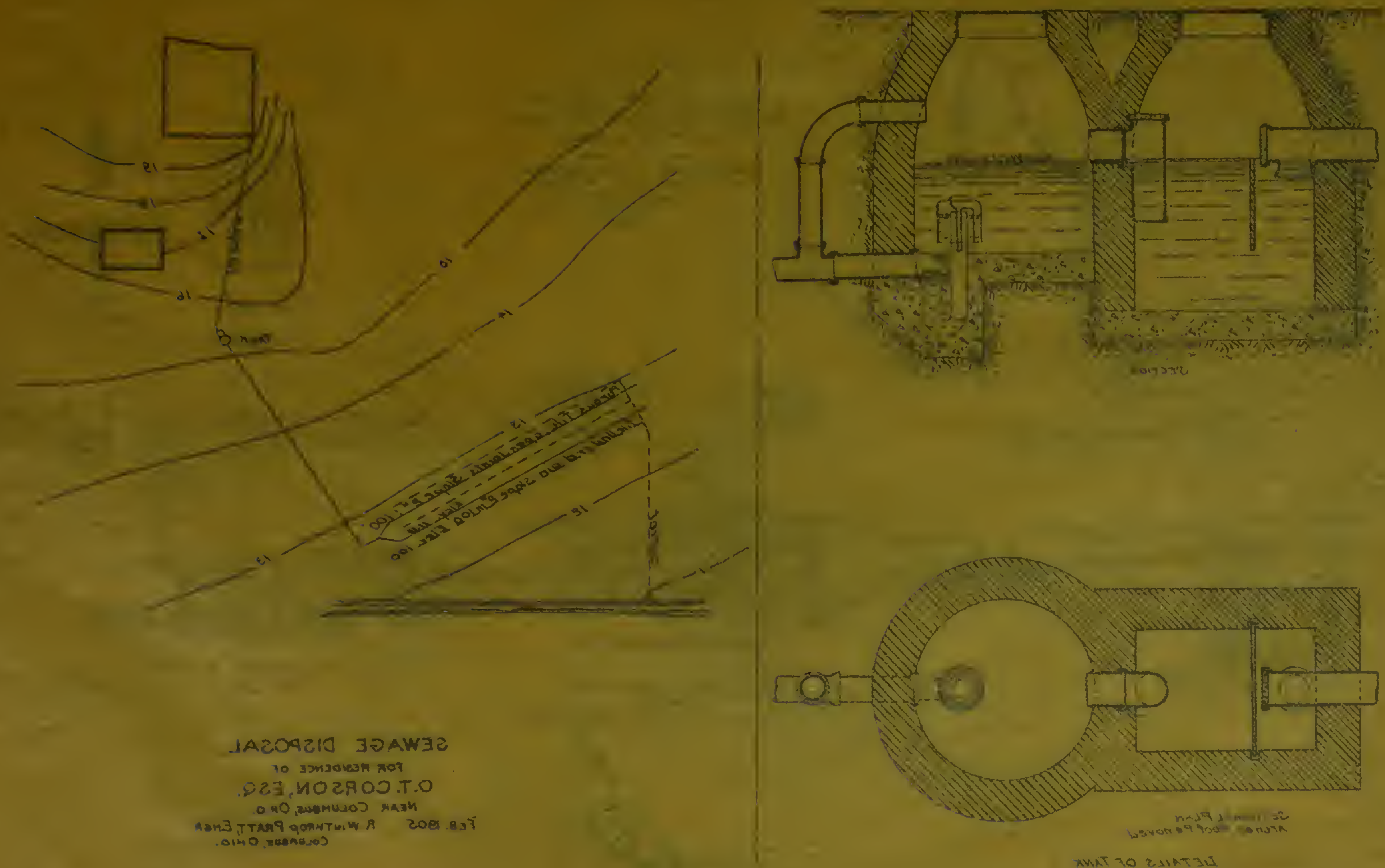
Data
75 People
50 Gal per Cap per Day
12 Hours Flow of Sewage Capacity

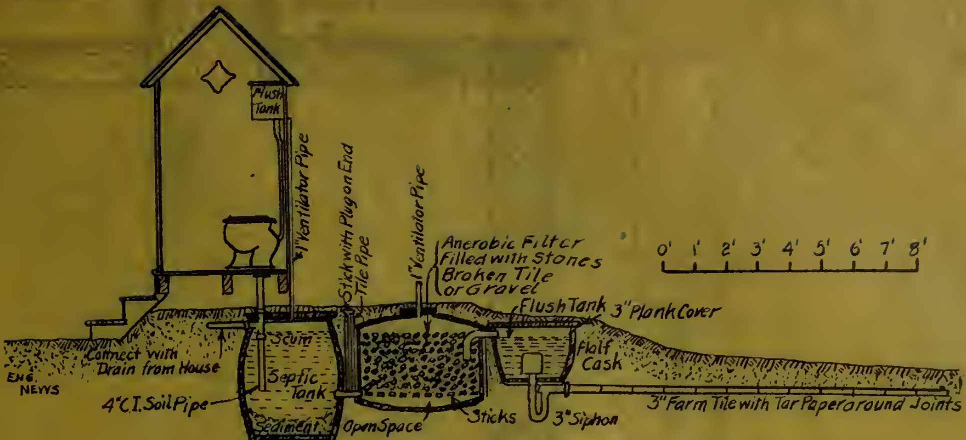
Scale 1/2" = 1'

W. T. McClenahan
Designer


PLANT FOR SEWAGE DISPOSAL
RAVISLOE COUNTRY CLUB
HOMEWOOD ILLINOIS
JOHN W. ALVORD
Sanitary Engr.
CHAS. B. BURDICK
Associate
1207 Hartford Bldg.
Chicago Ill.
1904
End
Outlet to Creek
Drain
Line #1 Filter Ditch Following Contour
250 Ft.
250 Ft
Line #2 Filter Ditch Following Contour of Ground
Anerobic Filter
Septic Tank
Inlet from House
General Arrangement Plant
Scale 1" = 40'
Screen
4'
Plan
Section A-B
Section C-D
Weirs
Scale 1/2" = 1'
Method of Laying Underdrains
Cap Tile
4" Drain
Flow Line
8'
2500 Gallons
Section-Septic Tank
18" Broken Tile 1" Ring
24" Broken Tile 2"
18" Coarse Material 4"
Clay
6" Siphon
Section of Anerobic Filter
Longitudinal Section Plant
Showing
GENERAL SCHEME OF PURIFICATION
Scale 1" = 1/4"
Screened Gravel
Pea Size
To Outlet
Cross & Longitudinal Sections
Filter Ditch
One Inch


HIGHWATER LINE
SECTION
SECTIONAL PLAN
Arched Roof Removed
DETAILS OF TANK
19
18
17
16
15
14
13
12
11
Vit. pipe
TANK
Porous Tile, open Joints Slope 2" : 100'
Elev. 118
Tile Underdrain Slope 2" in 100 Elev. 100
Outlet
SEWAGE DISPOSAL
FOR RESIDENCE OF
O. T. CORSON, ESQ.
NEAR COLUMBUS, OHIO.
FEB. 1905.
R. WINTHROP PRATT, ENGR.
COLUMBUS, OHIO.

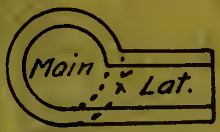

SEWAGE DISPOSAL
FOR RESIDENCE OF
O.T. CORSON, ESQ.
NEAR COLUMBUS, OHIO.
FEB. 1905 R. WINTHROP PRATT, ENGR.
COLUMBUS, OHIO.
SECTION
DETAILS OF TANK



SEPTIC TANK PLANT FOR COUNTRY RESIDENCES.
John W. Alvord, M. Am. Soc. C. E., Consulting Engineer, Chicago.

Sketch Showing Proper Junctions
Mains To Laterals.

Plan of Branch

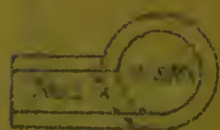


End View

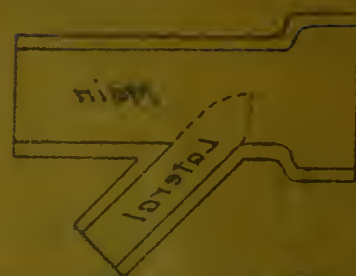
Sketch Showing Method of Laying Tile
With Troughs & Covers.

SEPTIC TANK PLANT FOR COUNTRY RESIDENCES
John W. Alvord, M. Am. Soc. C. E. Consulting Engineer, Chicago

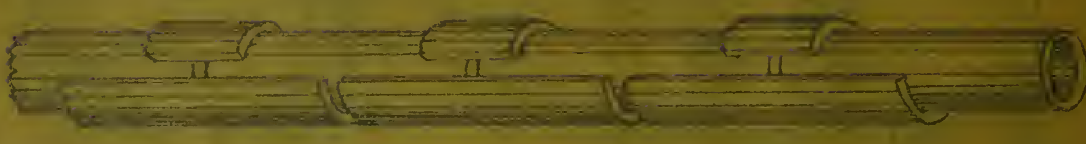
Sketch Showing Proper Junctions
Mains To Laterals



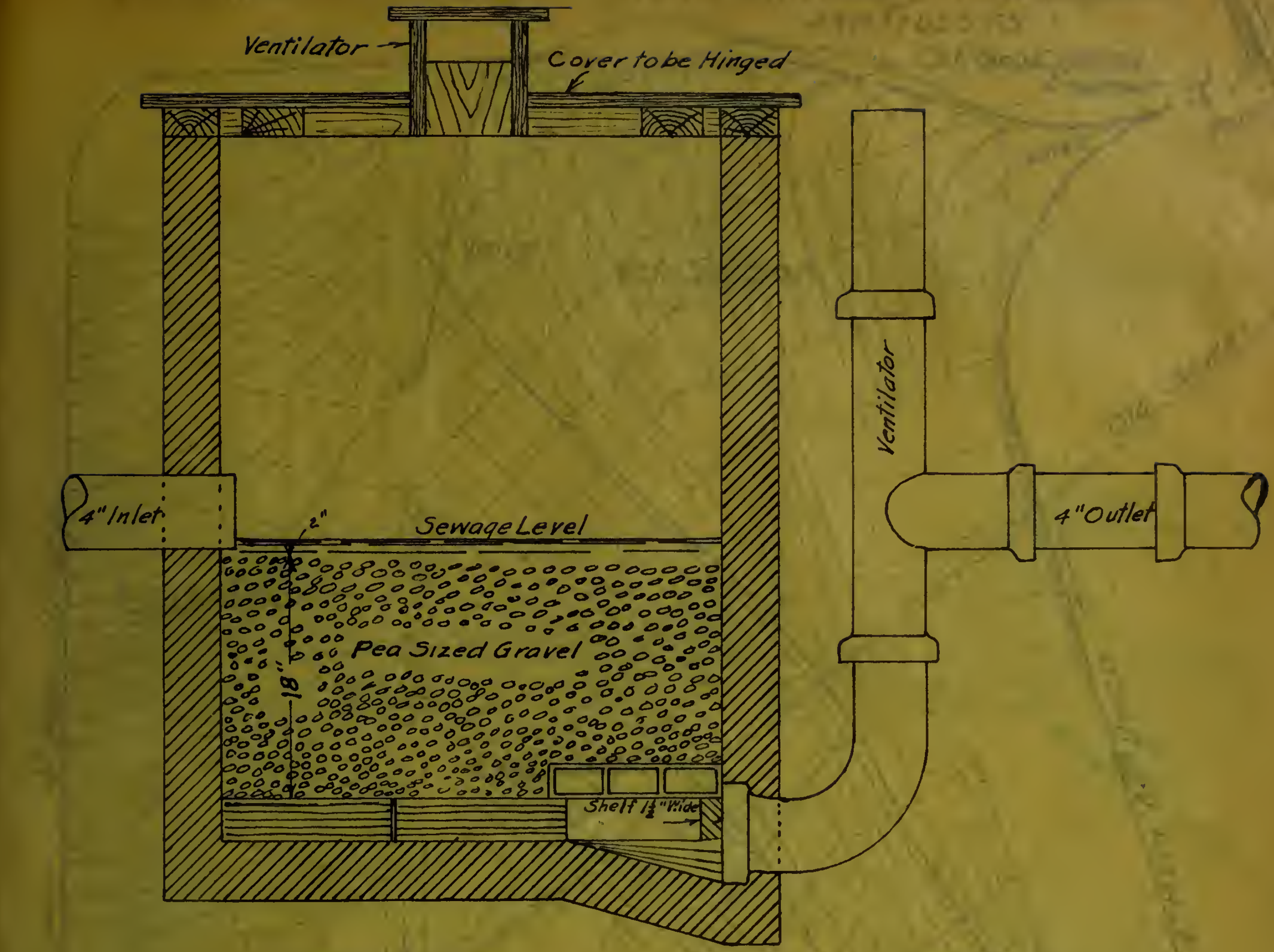
End View



Plan of Branch



Sketch Showing Method of Laying Tile
With Troughs & Covers.



SECTION A-A

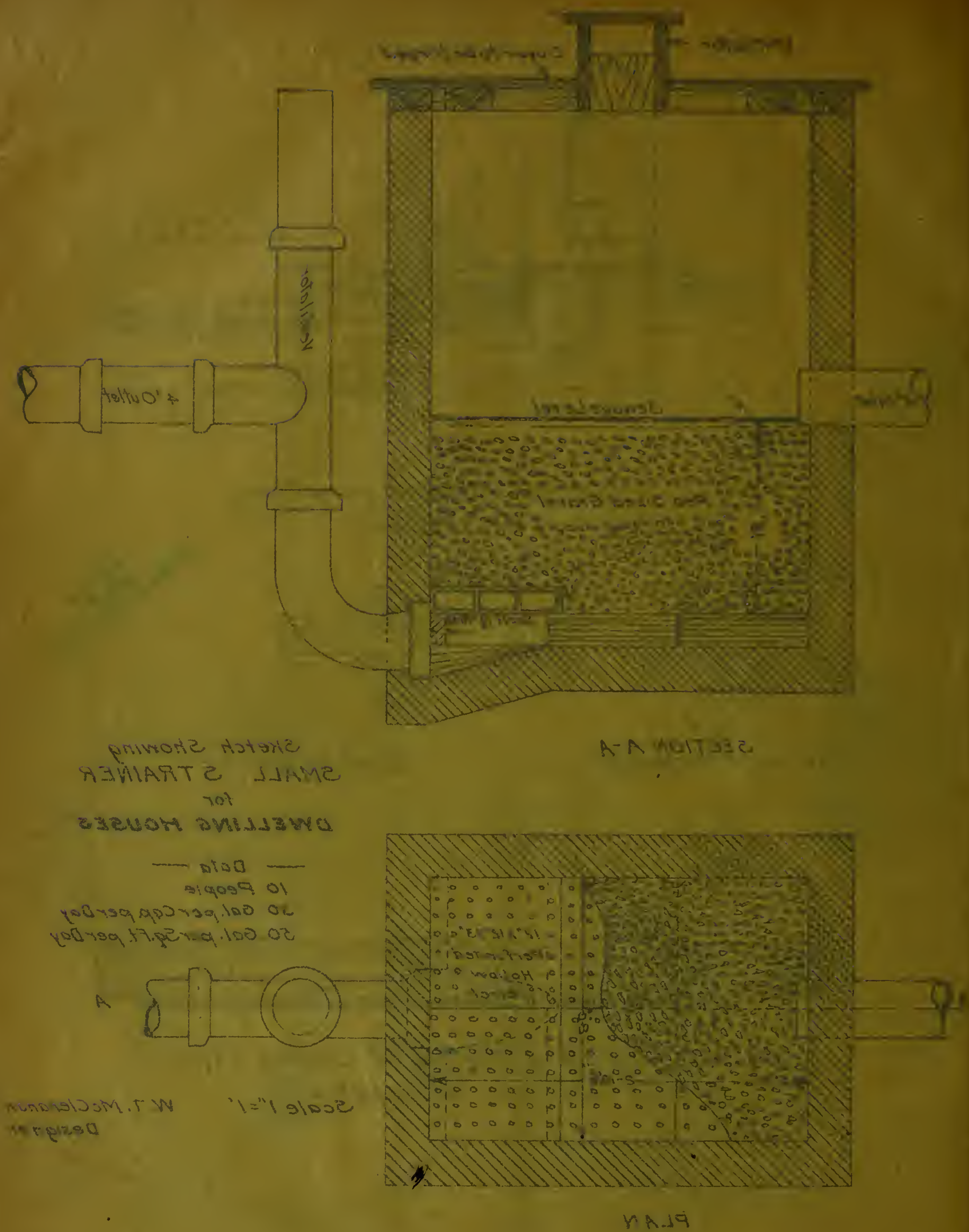
PLAN.

Sketch Showing
SMALL STRAINER
for
DWELLING HOUSES

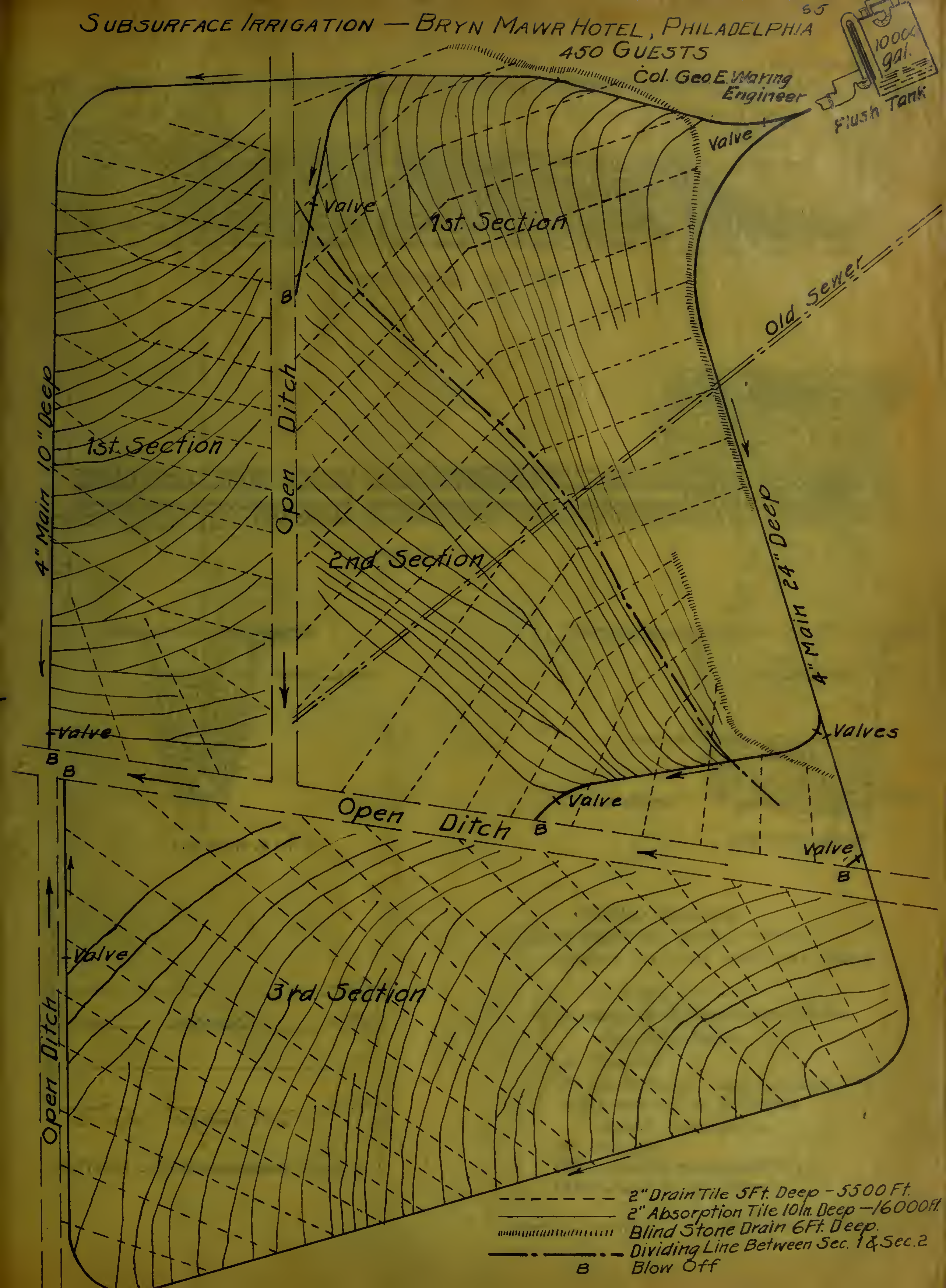
— Data —
10 People
30 Gal. per Cap. per Day
50 Gal. per Sq. Ft. per Day

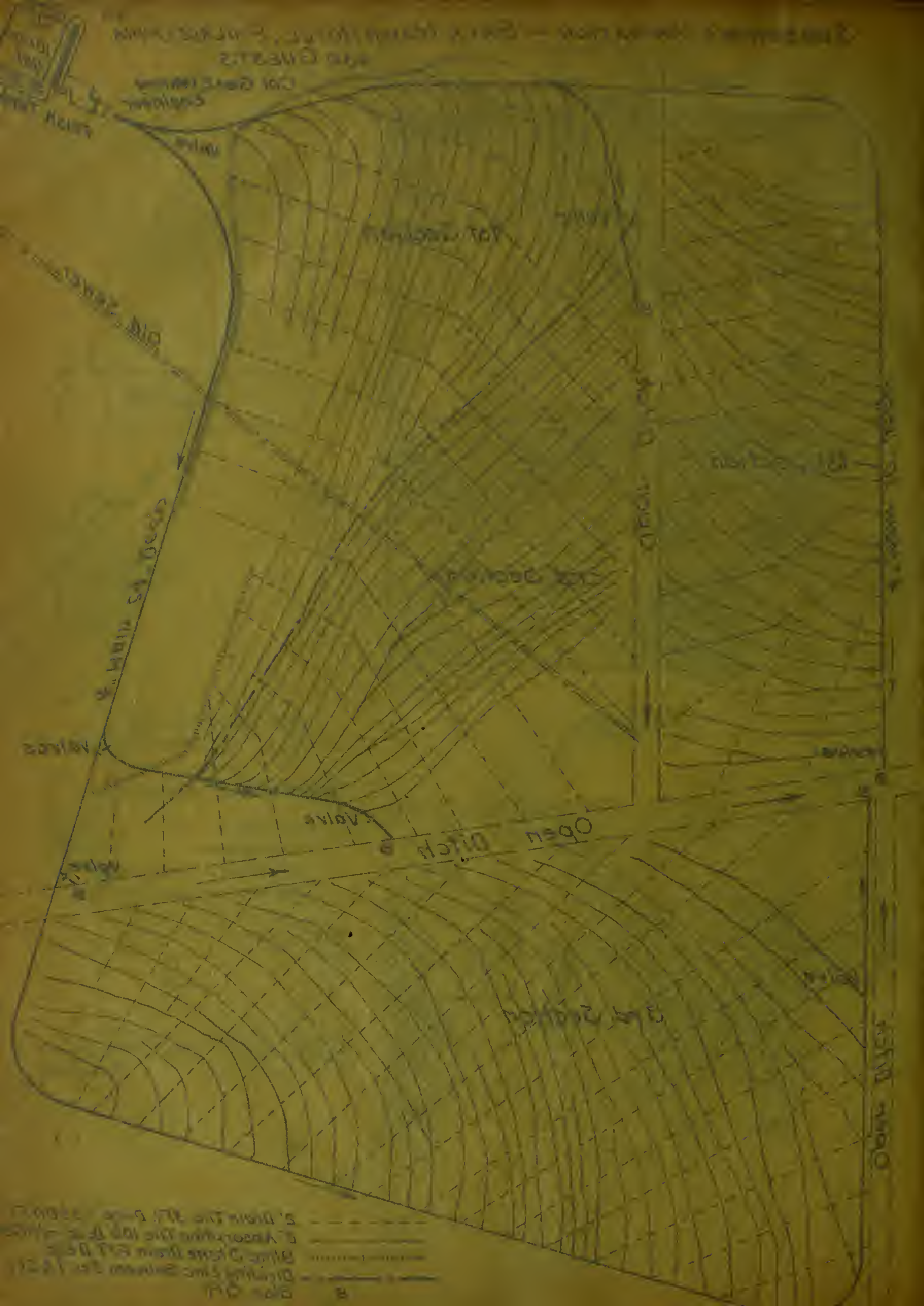
Scale 1" = 1'

W. T. McClenahan
Designer

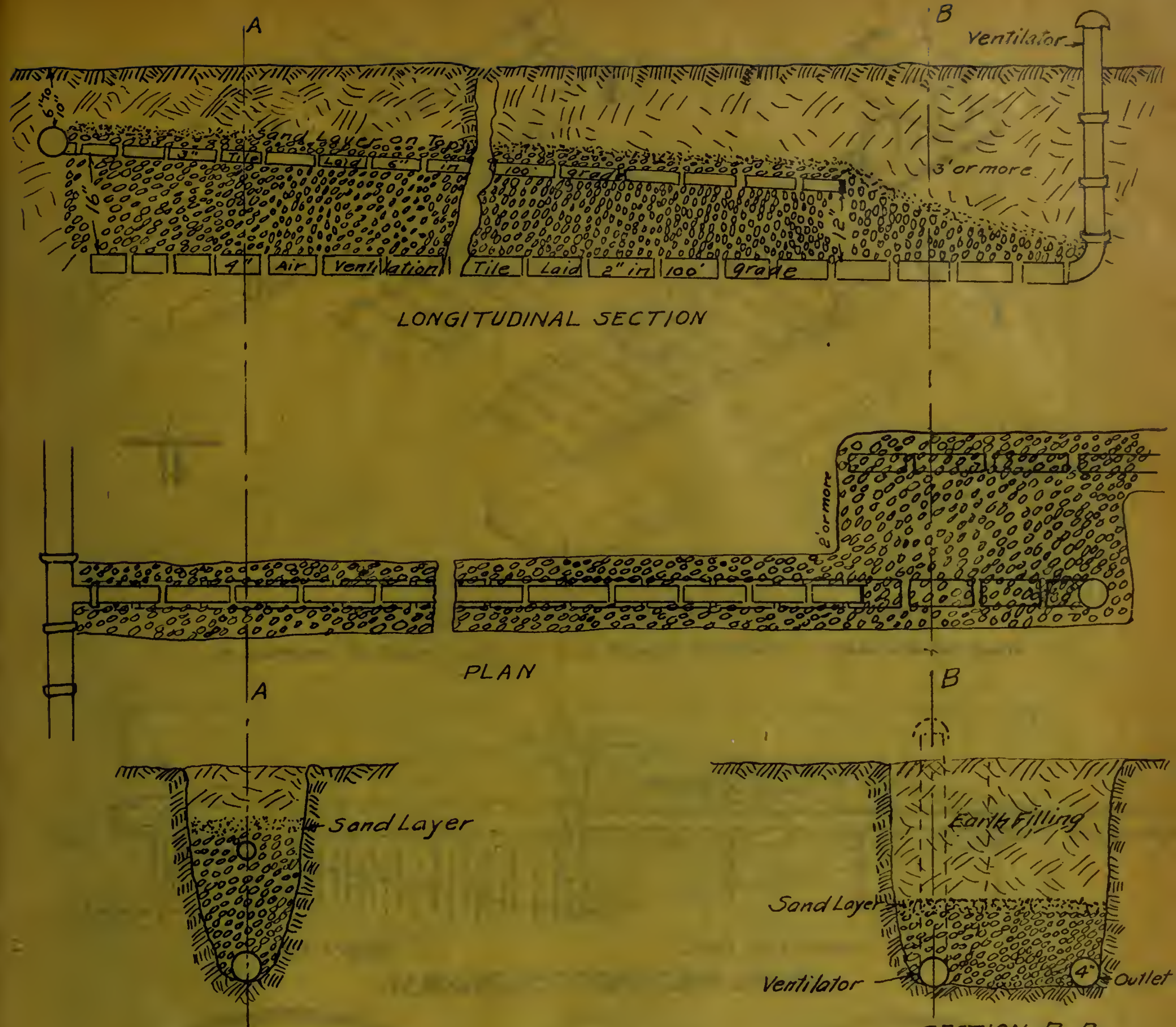


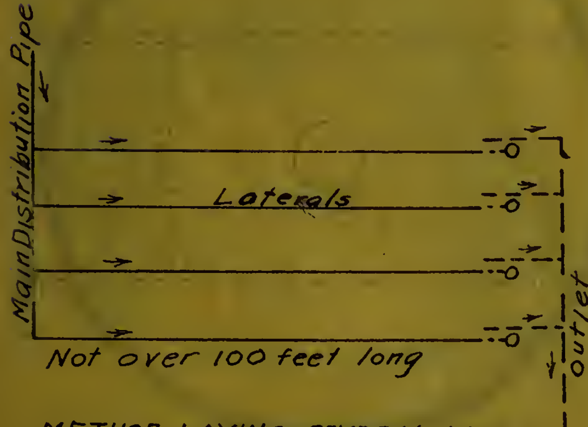
Ventilator
4" Outlet
Fine Sized Gravel
SECTION A-A
Sketch Showing
SMALL STRAINER
for
DWELLING HOUSES
— Data —
10 People
50 Gal. per Cap. per Day
50 Gal. per Sq. Ft. per Day
A
Scale 1"=1'
W. T. McClenahan
Designer
PLAN


SUBSURFACE IRRIGATION — BRYN MAWR HOTEL, PHILADELPHIA
450 GUESTS
Col. Geo. E. Waring
Engineer
10000 gal.
Flush Tank
Valve
1st. Section
B
Old Sewer
1st. Section
Open Ditch
4" Main 10" Deep
2nd. Section
4" Main 24" Deep
Valve
B
Valves
Valve
Open Ditch
B
Valve
B
Valve
3rd. Section
Open Ditch
2" Drain Tile 5 Ft. Deep — 5500 Ft.
2" Absorption Tile 10 In. Deep — 16000 Ft.
Blind Stone Drain 6 Ft. Deep.
Dividing Line Between Sec. 1 & Sec. 2
B Blow Off



Open Ditch
Valve
1st Section
2nd Section
3rd Section





METHOD LAYING SEVERAL LINES

Sketch Showing
SUB IRRIGATION DITCH WITH
GRAVEL FILLING FOR CLAY SOILS

— Data —

Assumed ½ Ft. Required to 1 Gallon.

Dwelling House

10 People

30 Gallons per Cap. per Day.

150 Linear Ft. of Laterals.

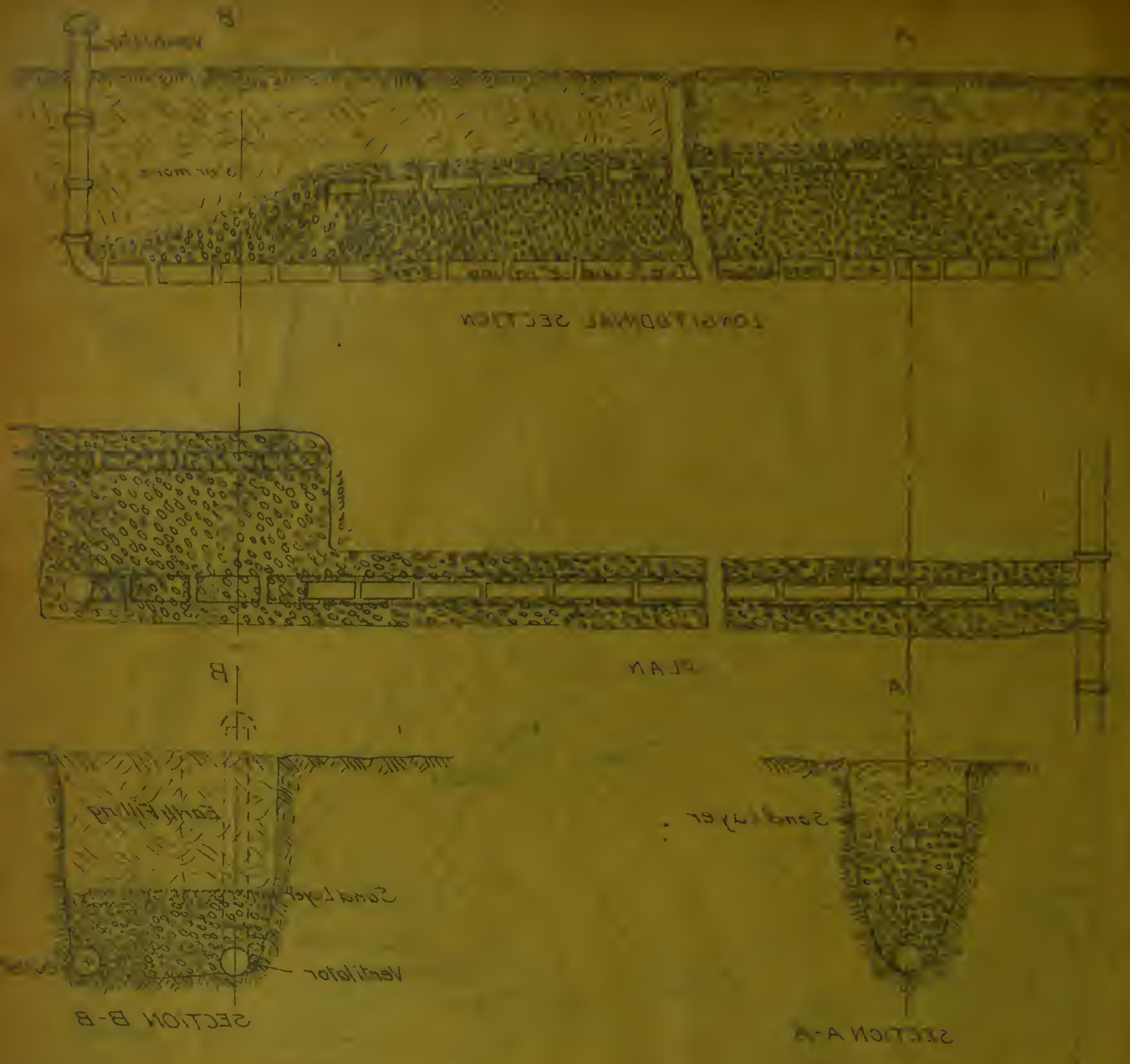
Small. Institutions

75 People

50 Gallons per Cap per Day.

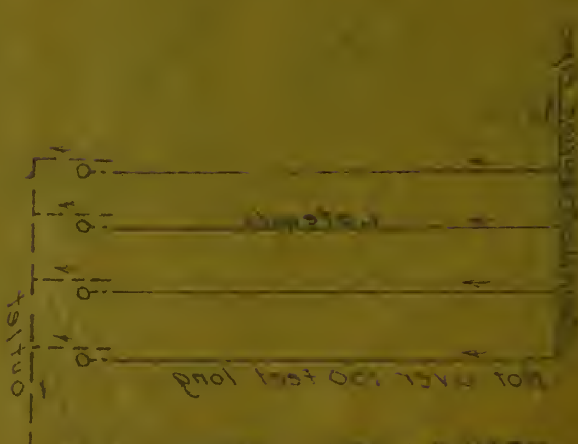
1875 Linear Ft. of Laterals.

Not to Scale. W. T. McClenahan.



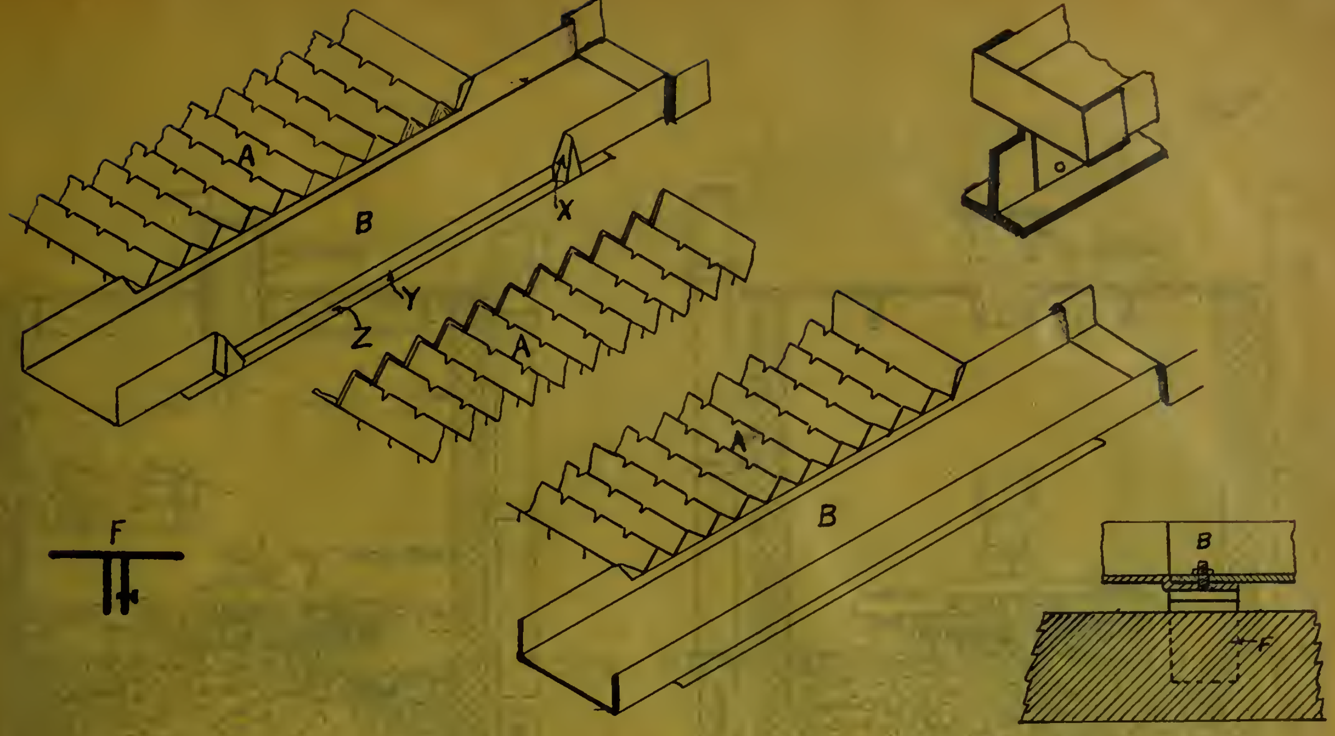
Sketch Showing
SUB IRRIGATION DITCH WITH
GRAVEL FILLING FOR CLAY SOILS

— Data —
Assumed ½ Ft Required to 1 Gallon
Dwelling House
10 People
30 Gallons per Cap per day
150 Linear Ft of Laterals
Small Institutions
75 People
50 Gallons per Cap per day
1875 Linear Ft of Laterals



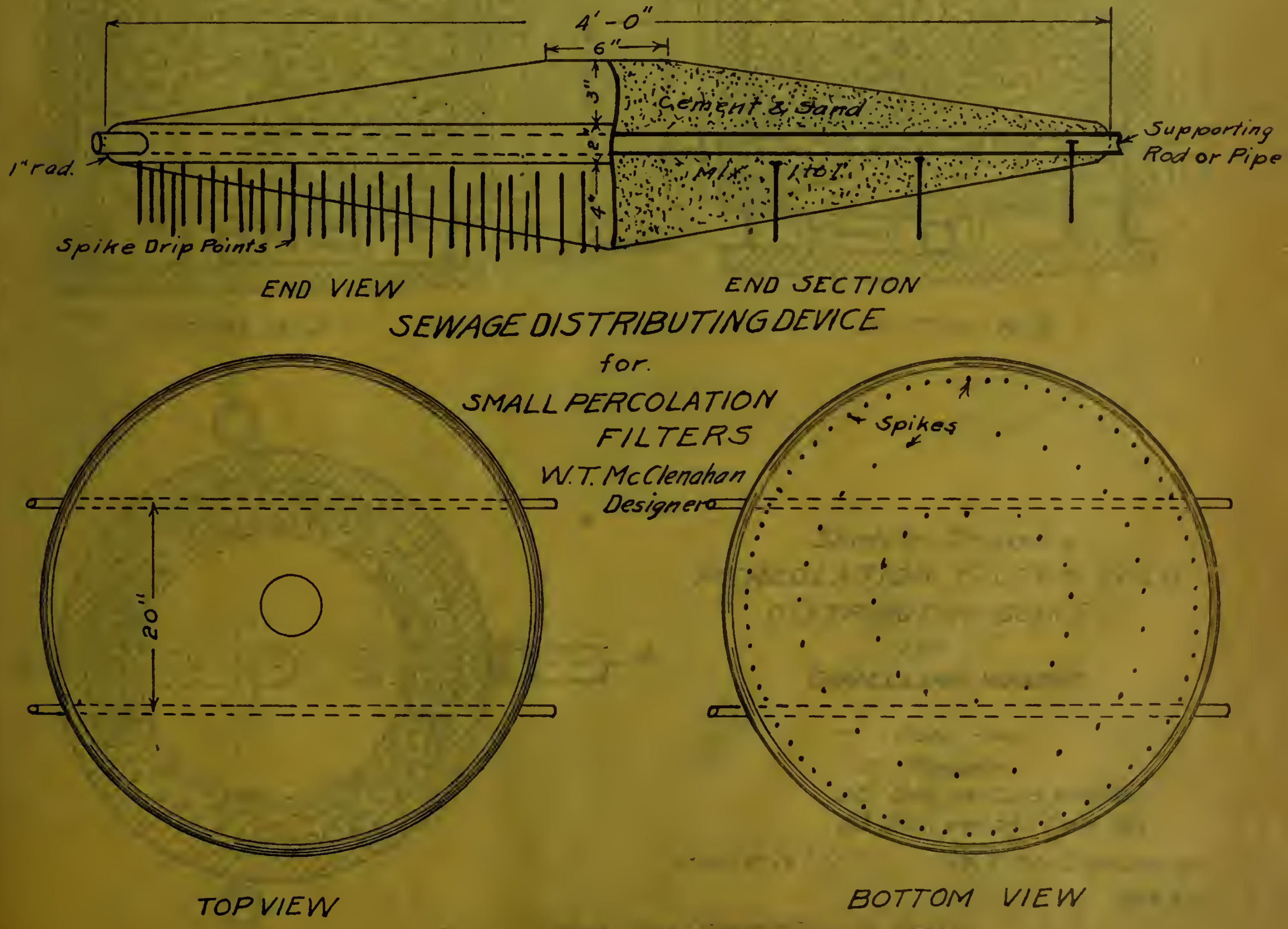
METHOD LAYING SEVERAL LINES

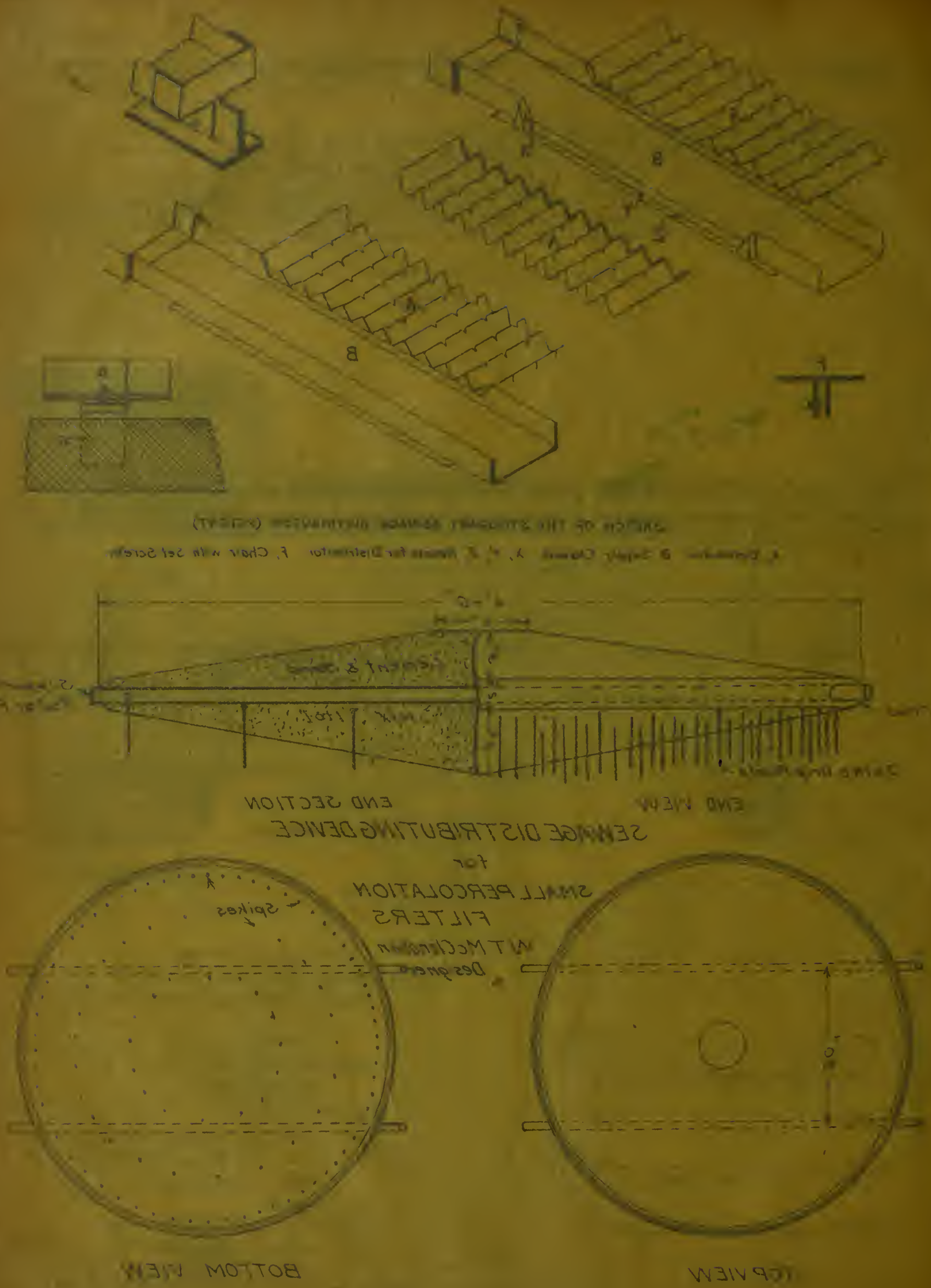
Not to Scale



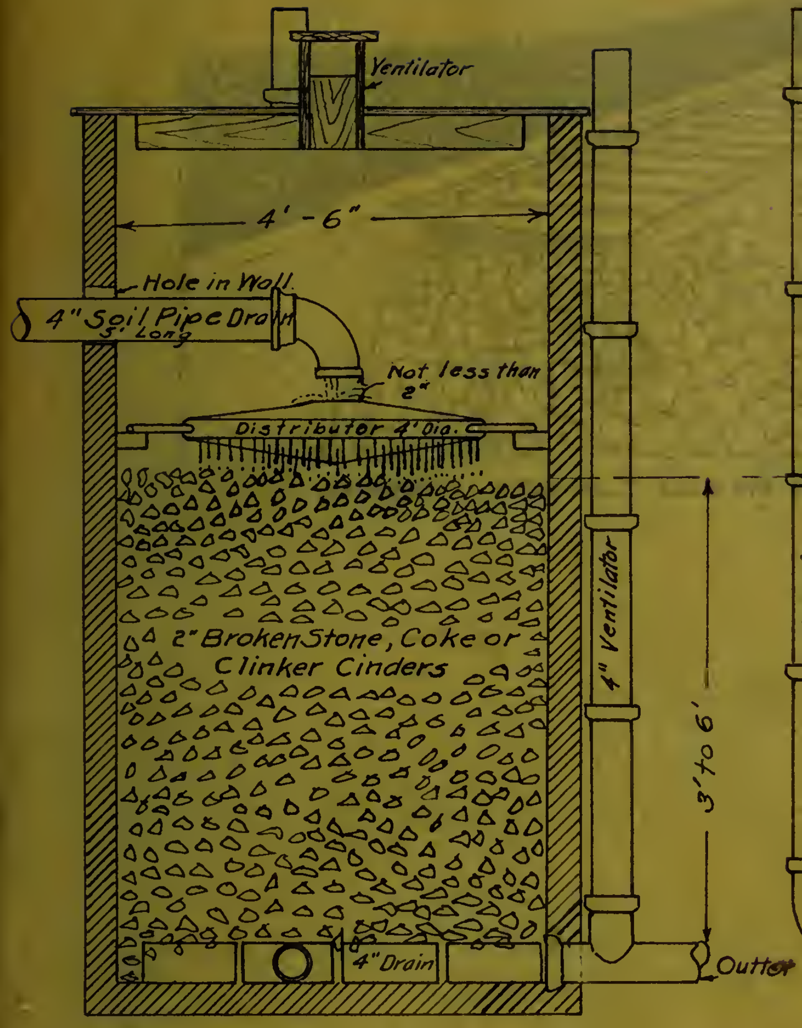
SKETCH OF THE STODDART SEWAGE DISTRIBUTOR (PATENT).

A, Distributor. B. Supply Channel. X, Y, Z, Recess for Distributor. F, Chair with Set Screw.

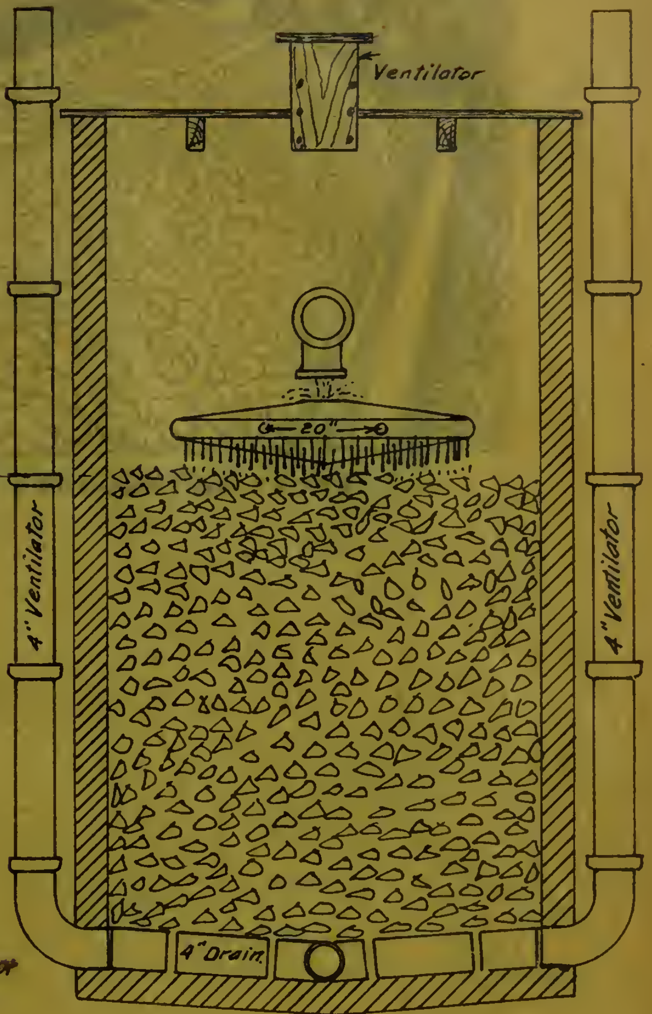




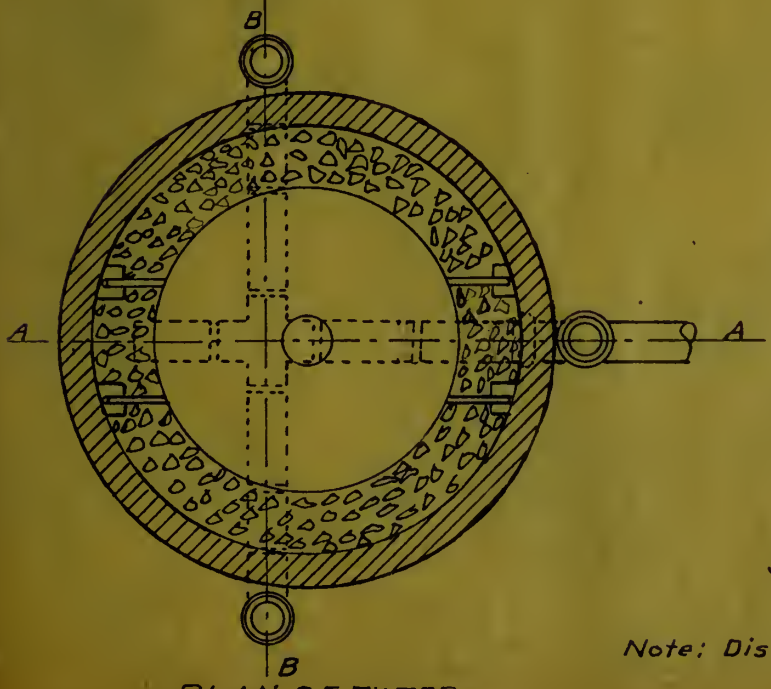
SKETCH OF THE STODDART SEWAGE DISTRIBUTOR (PATENT)
A. Distributor B. Supply Channel A, A', A'' Means for Distributor F. Chair with Set Screw
B
B
4'-0"
Cement & Sand
END SECTION
END VIEW
SEWAGE DISTRIBUTING DEVICE
for
SMALL PERCOLATION
FILTERS
W.T.McClenahan
Designer
Spikes
BOTTOM VIEW
TOP VIEW



SECTION A-A



SECTION B-B



PLAN OF FILTER.

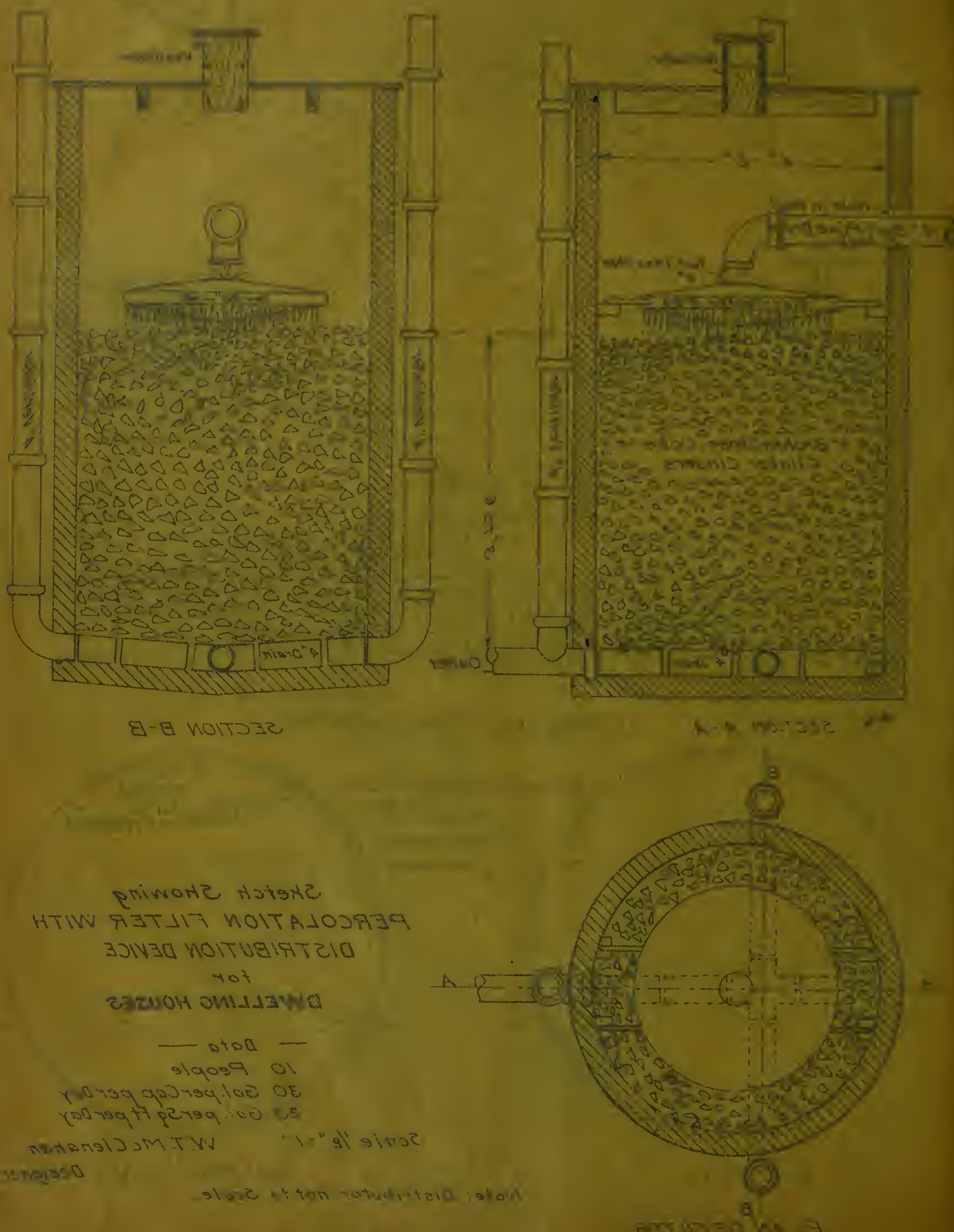
Sketch Showing
PERCOLATION FILTER WITH
DISTRIBUTION DEVICE
for
DWELLING HOUSES

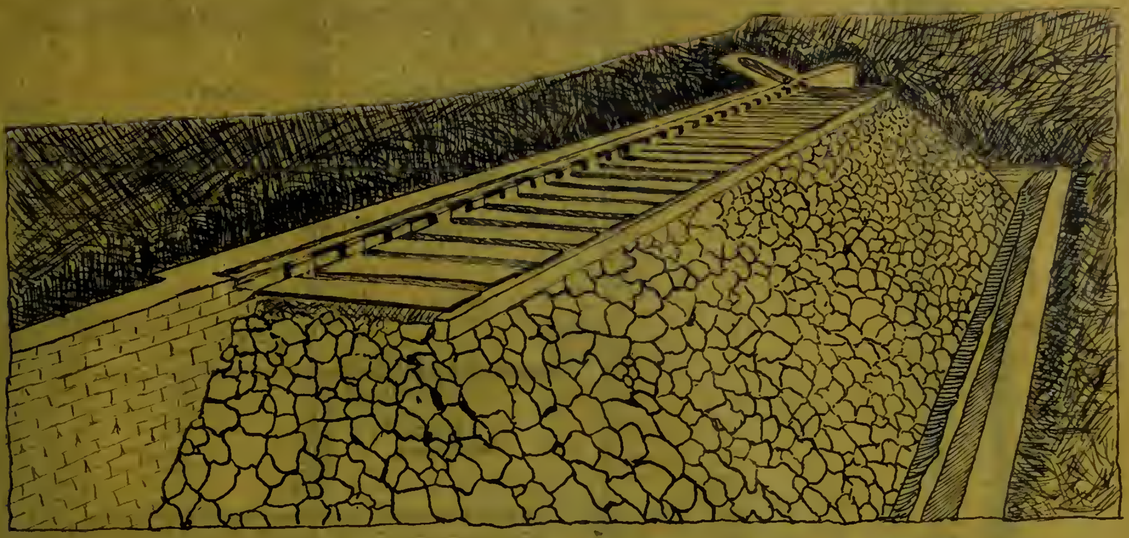
— Data —
10 People
30 Gal. per Cap. per Day
23 Gal. per Sq. Ft. per Day

Scale 1/2" = 1'

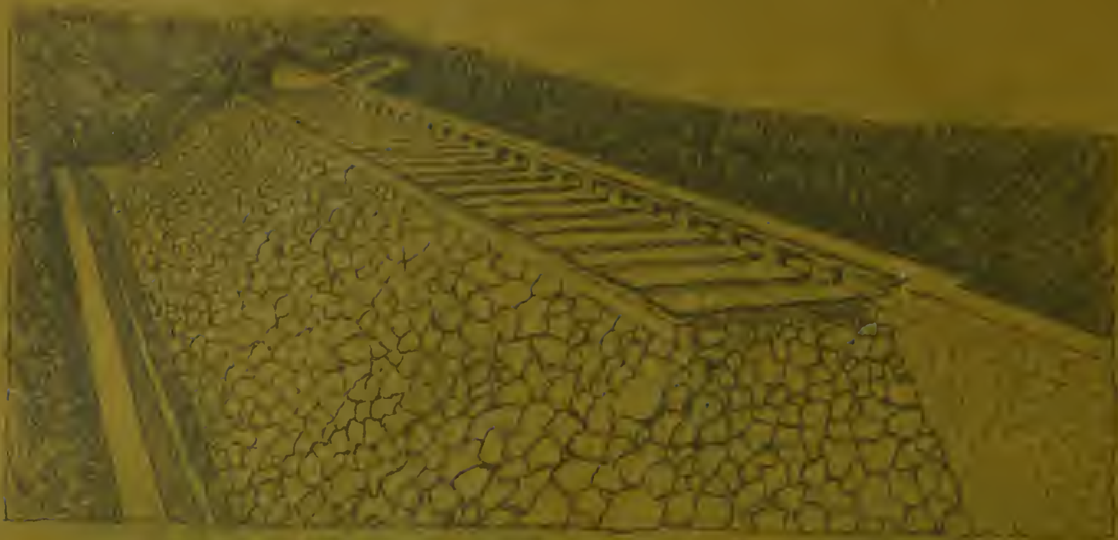
W. T. McClenahan
Designer.

Note: Distributor not to Scale.

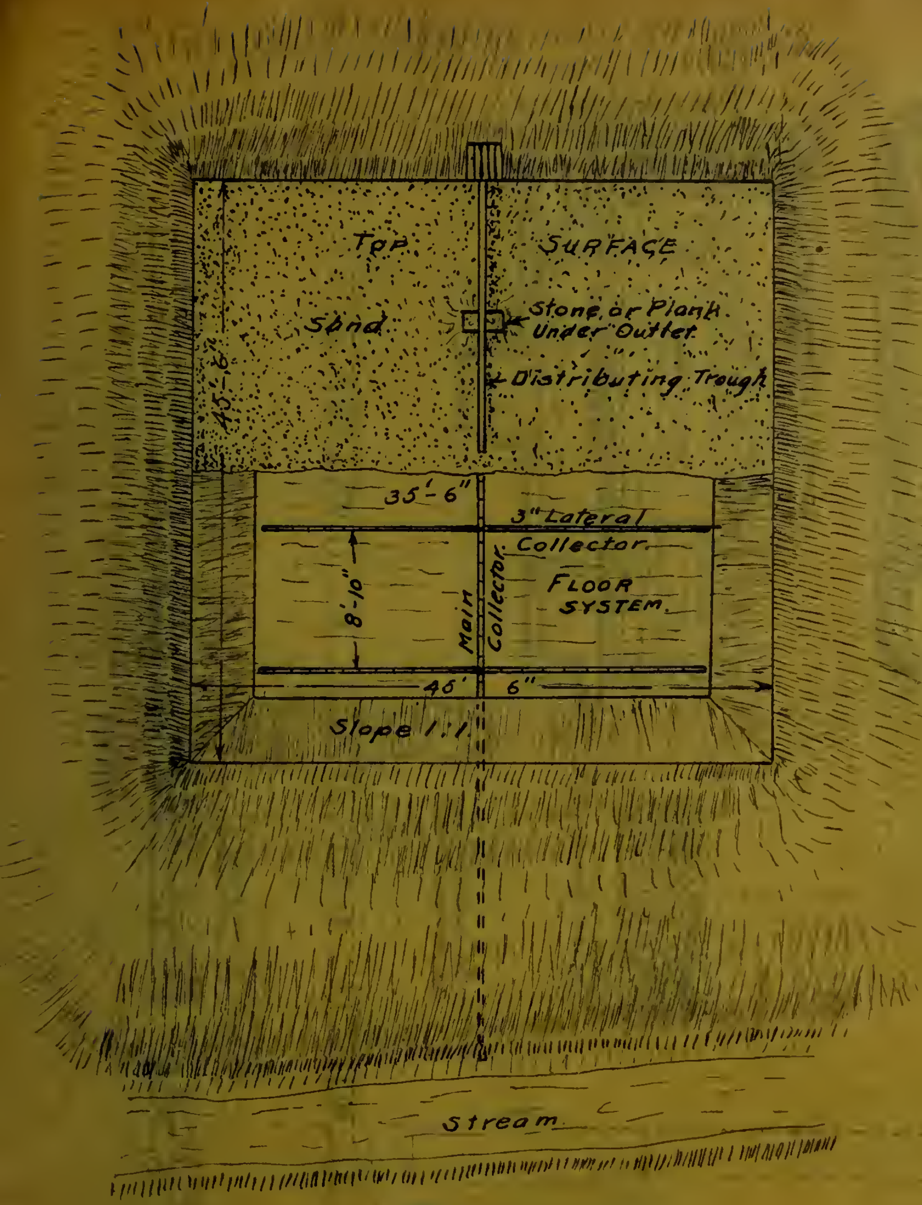

SECTION B-B
4" Drain
SECTION A-A
Outlet
3 ft 6"
PLAN OF FILTER
A
B
Sketch Showing
PERCOLATION FILTER WITH
DISTRIBUTION DEVICE
for
DWELLING HOUSES
— Data —
10 People
30 Gal. per Cap. per Day
Scale 1/2"=1'
W.T. McClenahan
Designer
Note: Distributor not to Scale.



STODDART TERRACE DESIGN PERCOLATING FILTER

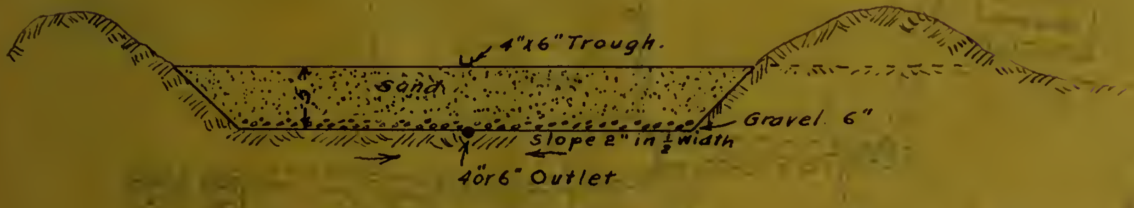


STANDARD TERRACE DESIGN PERCOLATING FILTER



PLAN of FILTER.

SECTION of FILTER on B-B.



SECTION of FILTER on A-A.

Sketch Showing
INTERMITTENT SAND FILTER FOR
SMALL INSTITUTION

Data

75 People using

50 Gal. per Cap. per Day.

2.3 Gal. per Sq. Ft. per Day.

Scale 1" = 15'

W. T. McClenahan.
Designer

PLAN of FILTER

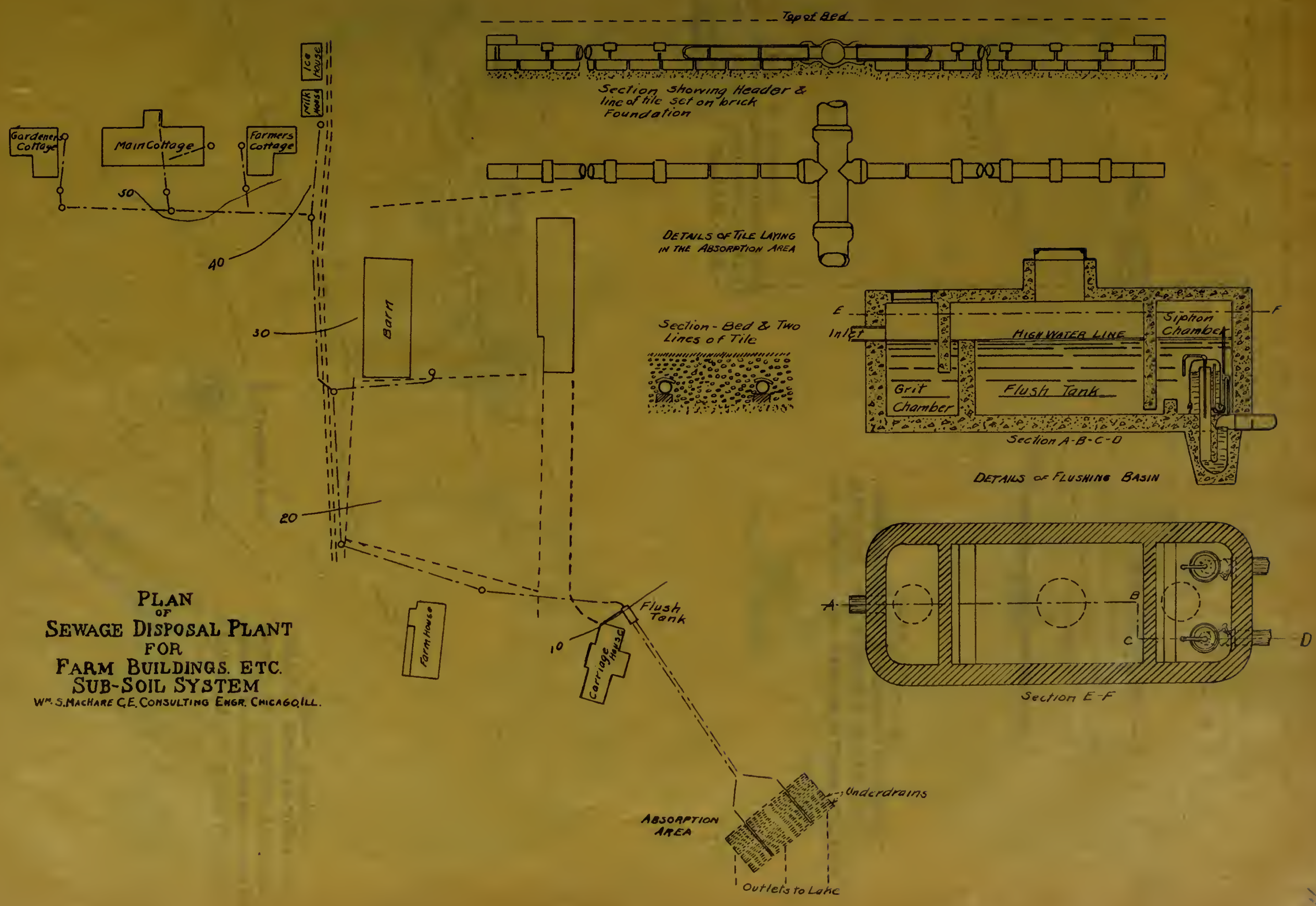
SECTION of FILTER on A-A

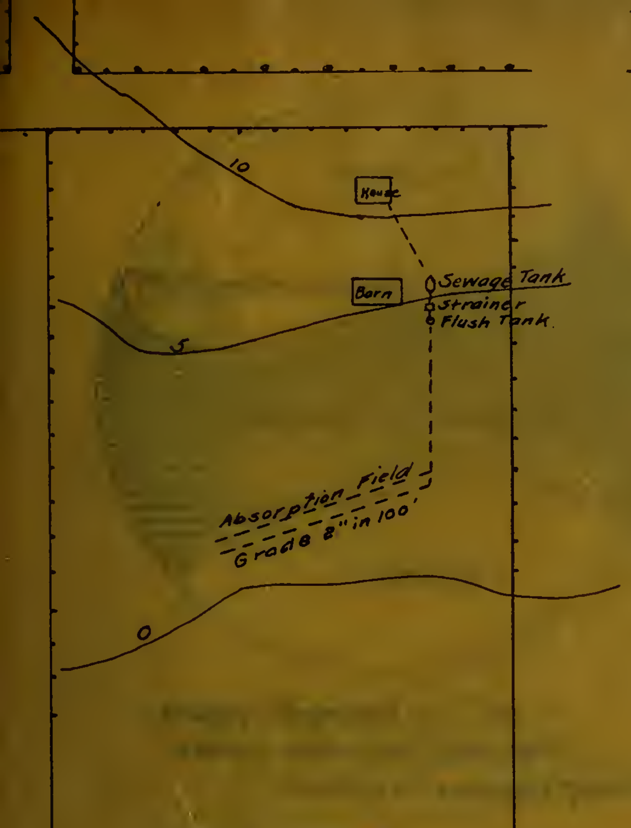
Sketch Showing
INTERMITTENT SAND FILTER FOR
SMALL INSTITUTION

Data
75 People using
50 Gal. per Cap. per Day
2.3 Gal per Sq. Ft. per Day.

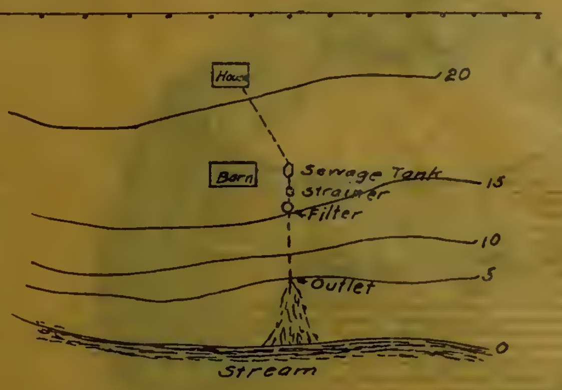
Scale 1"=15'

W. T. McClenahan
Designer

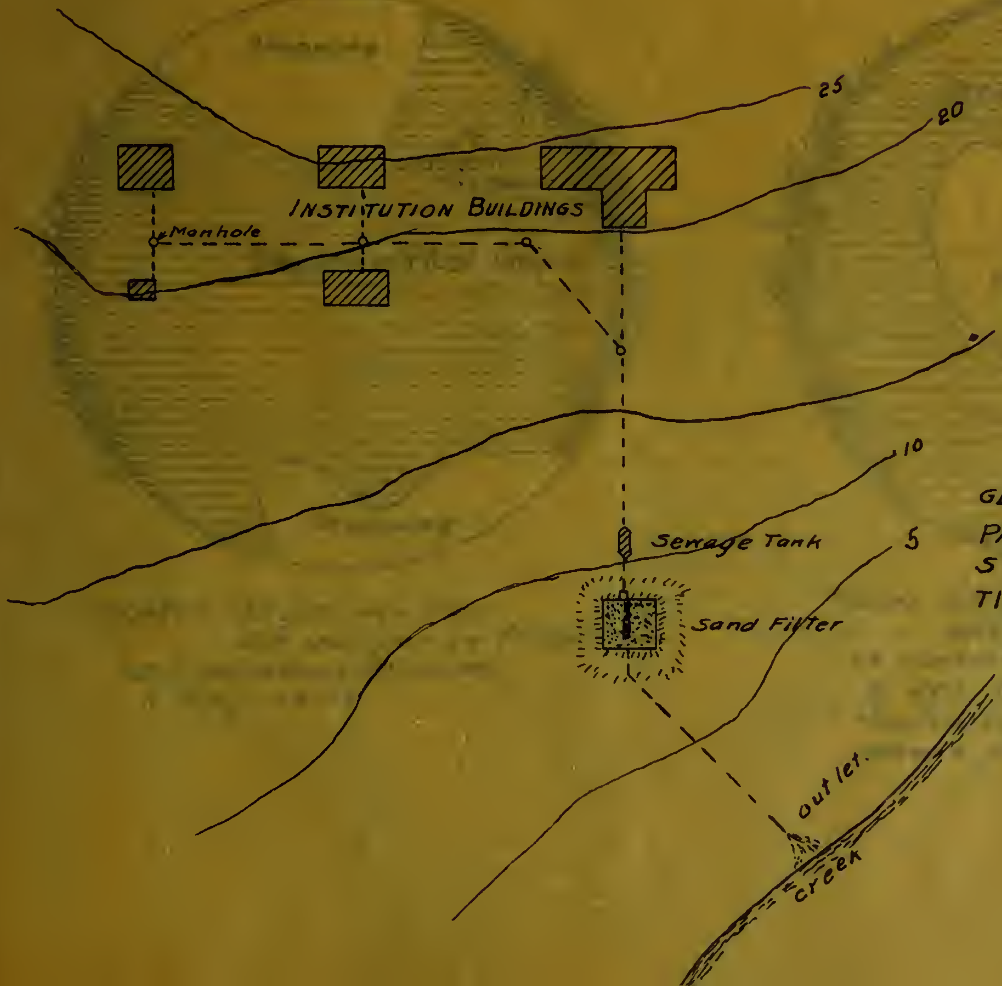

Top of Bed
Section showing Header & line of tile set on brick Foundation
Details of Tile Laying in the Absorption Area
Section - Bed & Two Lines of Tile
E
F
Inlet
High Water Line
Siphon Chamber
Grit Chamber
Flush Tank
Section A-B-C-D
Details of Flushing Basin
A
B
C
D
Section E-F
Gardeners Cottage
Main Cottage
Farmers Cottage
Milk House
Ice House
Barn
Farm House
Carriage House
Flush Tank
50
40
30
20
10
Absorption Area
Underdrains
Outlets to Lake
PLAN OF SEWAGE DISPOSAL PLANT FOR FARM BUILDINGS. ETC. SUB-SOIL SYSTEM
Wm. S. MacHarg C.E. Consulting Engr. Chicago, Ill.



Sketch Showing
ONE ARRANGEMEN SUGGESTED FOR SEWAGE DISPOSAL IN FLAT COUNTRY BY **PLAIN SUB-IRRIGATION**



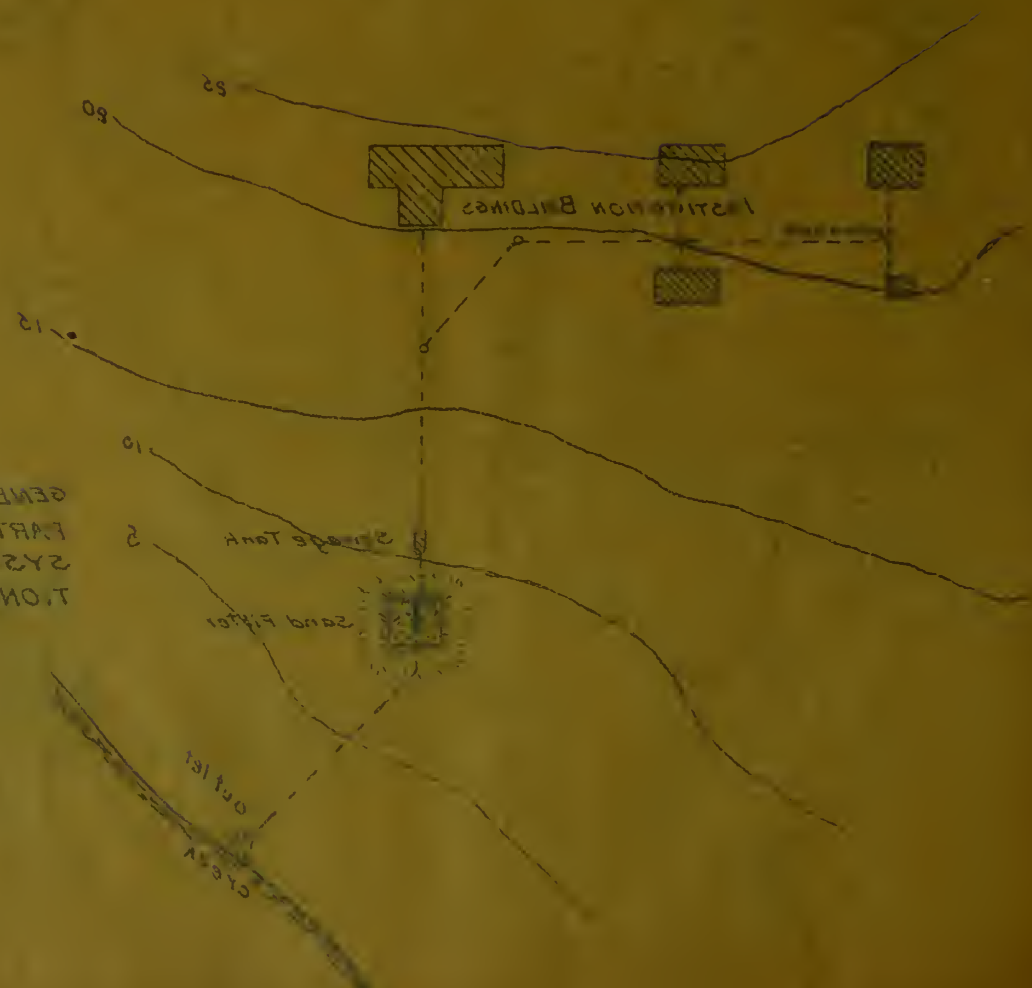
Sketch Showing
ARRANGEMENT & SUGGESTED BEST DESIGN FOR SEWAGE DISPOSAL ON A BLUFF BY **PERCOLATING FILTER.**



Sketch Showing
GENERAL ARRANGMENT OF PARTS OF SEWAGE DISPOSAL SYSTEM FOR SMALL INSTITUTIONS USING SAND FILTER.

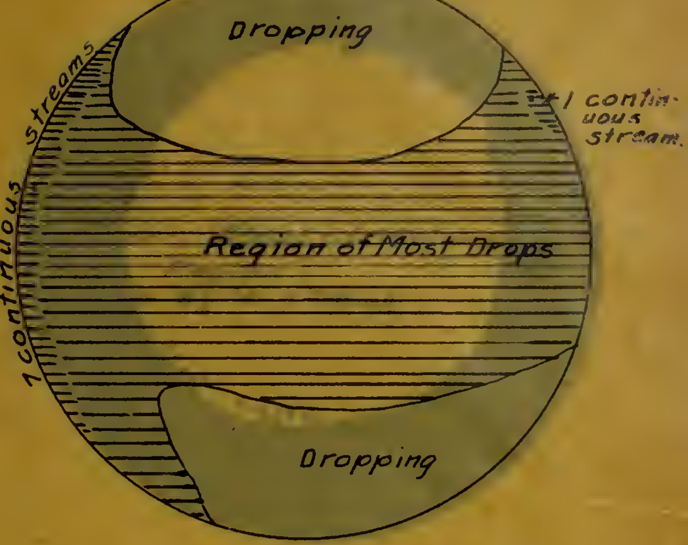
Sketch Showing
ARRANGEMENT & SUGGESTED BEST
DESIGN FOR SEWAGE DISPOSAL
ON A BLUFF BY PERCOLATING FILTER.

Sketch Showing
ONE ARRANGEMENT SUGGESTED
FOR SEWAGE DISPOSAL IN FLAT
COUNTRY BY PLAIN SUB-
IRRIGATION

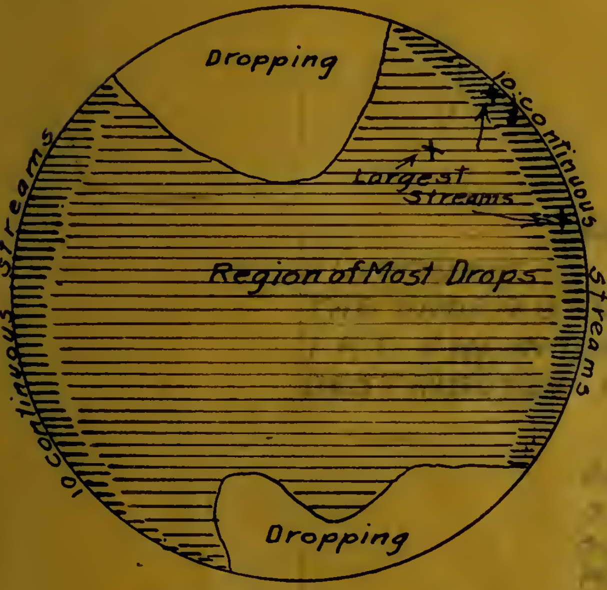


Sketch Showing
GENERAL ARRANGEMENT OF
PARTS OF SEWAGE DISPOSAL
SYSTEM FOR SMALL INSTITU-
TIONS USING SAND FILTER

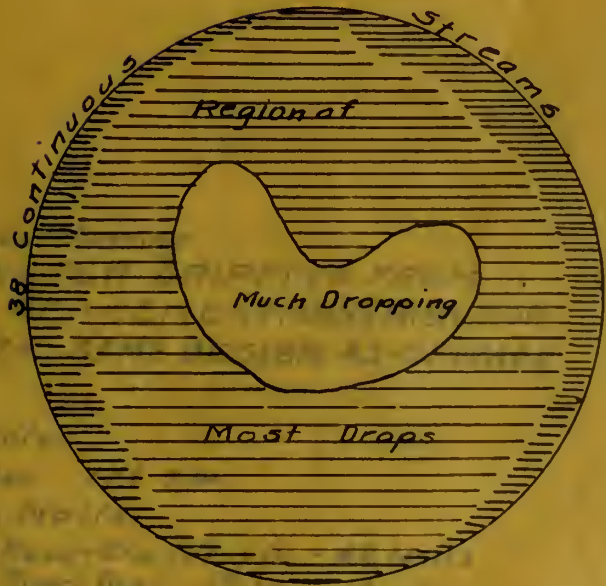
Water Applied at Top —
Rates; .0904 gal. per min.
.0458 gal. per sq. ft per min.



Rates: .258 gal. per min.
.131 " " sq. ft. per min
Only 6 nails not dripping
Water well distributed over the area.

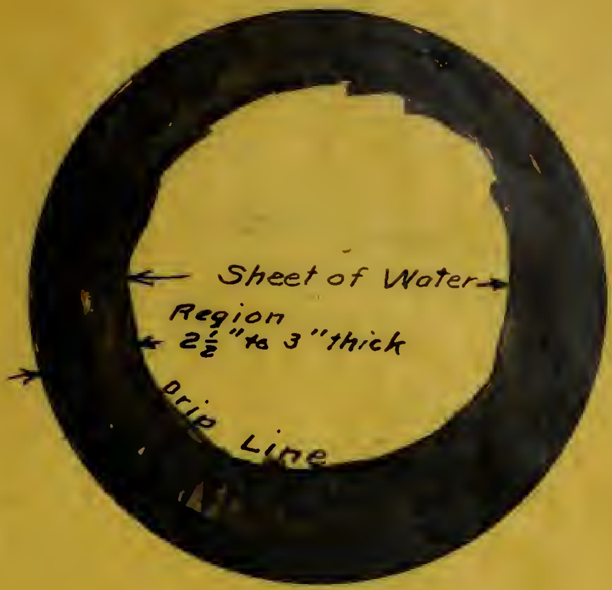


Rates .53 gal. per min.
.269 gal. per sq. ft. per min.
20 continuous streams.
5 dry nails.



Rates .84 gal. per min.
.426 gal. per sq. ft. per min.
38 continuous streams.
4 dry nails.–1 in. cercumference.
Much dripping from points where no nails are placed.

Rates 3.85 gal. per min.
1.95 gal. per sq. ft. per min.
3 dry nails - none in the circumference.



Rates 9.23 gal. per min
.469 gal. per sq. ft. per min.
1 dry nail (in center.)

Sketches Showing

DISTRIBUTION OF WATER DRIPPING FROM THE UNDER SURFACE OF A CEMENT DISTRIBUTOR 1 FT. 7 IN. IN DIAMETER,- SAME DESIGN AS SEWAGE DESTRIBUTER PAGE

Data.

Diameter 1 Ft. 7 In.

3 Rows Nails

Outside Row - Dia.	1 Ft. 3 In.	-	42 Nails
Middle Row - Dia.	10 In.	-	8 "
Inside Row - Dia.	6 In	-	16 "

Total Number Nails 66

Tested by W.T. McClenahan.