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The Bacterial Disposal of Sewage.

BY G. EVERETT HILL.

It will be my endeavor to night to condense within the limits of your patience the salient points which will explain (1) why sewage disposal is of vital interest to a community, (2) the various methods of sewage disposal in use, and (3) the comparative value of these methods.

Whether recognized or not, the mainspring of all human activities, whether physical, mental or spiritual, is the desire to acquire. To get—to have—to enjoy—these are the longings of all; differing widely in manifestation with the individual, but springing from the same principle.

Our lives have grown very complex. Things which our ancestors never saw are necessities to-day; and what we see in Nature's storehouse and want, we do not hesitate to appropriate. We kill the cattle, we cut down the forests, we tear the iron and coal from the bowels of the unwilling

earth; we even appropriate the air and sunshine and use them as slaves to drive our motors and paint our pictures. All this is progress, and a certain measure of progress in acquisition is called civilization.

But acquisition and use must always be followed by consumption and rejection of the products of consumption. Our track of progress is really a trail of desolation strewn with ashes, excrement and rubbish. Even the air is polluted and the sunshine darkened by the smoke and noisome exhalations poured from our factory chimneys. In our instincts of rejection we are still little more than savage. Until *very* recently, few, save perhaps the barbarous Chinaman, dreamed of putting his wastes to any use. Things which we do not want we throw away, and that is the end of our interest in them. Even the poet—who is supposed to be an idealist—instead of putting his rejectamenta into the rubbish barrel or some other suitable place, unblushingly says:

“ Behind us, *in our path*, we
Cast the broken potsherds.”

The sailor alone, who has had an experience denied to the poet, has modified this promiscuous discarding of wastes by insisting that hot ashes—and certain other things—be not thrown to windward.

Seriously, I have not overstated the case. Can we rightly boast of national civilization when less than 4 per cent. of the communities in our country have adopted means for the hygienic disposal of filth; and when the sixth city of the land is riddled—under buildings as well as under yards and streets—with cesspools, whose overflow babbles noisily and noisomely in the street gutters?

But man is learning. So long as the area surrounding his habitation was large, he suffered little recognized inconvenience. But when the farm became a village and the village a town—as the land was divided and subdivided and the houses and population multiplied—he was brought into closer relations with his own offscourings; offense and disease resulted, and it gradually dawned upon his consciousness that either he or it must get off the premises. Consequently, he sought for a new place in which to throw

it, and, grumbling about the cost, built a sewer to the nearest stream. He thought only of transferring the offense to some point beyond the reach of his senses—not of destroying it.

But an epidemic broke out in a town below, which used this stream as a source of water supply; and the resulting suffering and death were found to be entirely chargeable to the community which had “thrown away” its sewage into the stream. The courts were invoked, and future pollution of the stream was forbidden. What could be done with the sewage, now greater in volume than ever and still increasing? The ocean was too remote to be reached; there was no mighty river available which could serve as an outlet.

Then man began to think and to study. He found that sewage was not irredeemable filth. He learned that nature, if encouraged, would turn his foul and poisonous offscourings into clean and harmless mineral forms, and would restore to contaminated water its original purity. He learned, moreover, that this could be done without offense, and close to his own home; that there need be no accumulation of filth, nor any pollution of streams or other infringement of a neighbor's rights; that death-rates can be lowered; that suffering and the expense of sickness can be lessened, and the period of productiveness lengthened.

He *thought* for a while that he had learned more than this. Necessity is a very fecund mother of invention; but, sad to say, prescience is not always the father. The offspring were patents—patents by the score, by the hundred—myriads of patents for “improved” processes of sewage disposal. The sifting of this innumerable company of patents was a long and tedious process. Most of them proved worthless. A few are of great value. The most beautiful children are not always the best, and the processes which brought the bitterest disappointment were those beatific ones which promised financial return from the recovery of valuable constituents of the refuse. Fortunes untold have been sunk in the attempt to make the collection and treatment of sewage profitable. It is true that some pecuniary return may be expected from processes which

are available for use under certain conditions, and such return should be welcomed as a valuable factor in reducing the cost of treatment; but it is not safe to build upon any foundation other than this; *i. e.*, that the disposal of refuse is a vital and costly necessity, a just tax upon those whom it benefits, and that its charges must be estimated as a part of the price of living and paid accordingly.

Self-betterment *per se* cannot be forced upon the individual or the community by any outside influence; but the courts will protect an individual threatened by his neighbor, or a town whose health and comfort are menaced by the act of another town. The common law on the subject is clear and comprehensive; but the growing realization of the danger and the wantonness of stream pollution have led to special and stringent legislation in many of the States. Massachusetts, Ohio, New York, Minnesota and West Virginia were the pioneers in this work. Connecticut and New Jersey seconded them nobly.

In Pennsylvania, I am sorry to say, the bills intended to preserve the lives and the health of the people, by preventing the pollution of water-courses, have been invariably killed by the manufacturing interests, because, forsooth! it is cheaper to poison God's brooks and rivers than to remove or clean their own offscourings. What matters the sickness of the children, the death of breadwinners, if only the brute, commercial industry, is fed!

“ Thus they fling him, hour by hour,
Limbs of men to give him power,
Brains of men to give him cunning,
And, for dainties to devour,
Souls of children, little worth,
Hearts of women, cheaply bought.
He takes them and he breaks them,
But he gives them scanty thought.”

Perhaps you think I speak bitterly. But I know the iniquity; I have seen the harvest. I am now watching, with the gravest apprehension, a case where a State institution of the Commonwealth of Pennsylvania is pouring the sewage from nearly a thousand people into a stream which one can

cross dryshod on stepping stones, while, less than two miles below, lies the water-intake of a town of considerable size. The sentiment of it all is disgusting enough; but one spark of typhoid at the institution above, one moment of carelessness on the part of the nurse in charge and—Heaven help that town!

Before describing the processes which enable us to dispose of our wastes hygienically, let us make sure that we understand what sewage is. Many people conceive it as a dark, turbid, foul-smelling liquid, the very incarnation of concentrated nastiness. As a matter of fact, *fresh* domestic sewage is almost clear, almost odorless and quite inoffensive. One can get a good idea of its appearance—and, what is more, a typical sewage for experimental purposes—by adding a tablespoonful of milk to a pail of water. Floating in this liquid are occasional solid particles of a hundred different kinds, yet strangely alike when their chemical constituents are considered.

Normal sewage contains, in a thousand parts, 998 parts of pure water, one part of mineral matter (largely salt), which is entirely harmless, and one part of dead organic matter. This last named item—insignificant in bulk, for it is but one-thousandth of the whole volume—is the only part that need be considered, for it alone is capable of mischief.

Organic matter is composed, practically, of three mineral elements—carbon, nitrogen and hydrogen—each inoffensive by itself or when combined with oxygen. These elements have been drawn from the soil by vegetation, and the vegetation, in turn, has perhaps been devoured by animal life and appropriated to the building up of its tissues. As these tissues are consumed in vital activities and replaced by fresh structure, they are discarded, and it is at this stage that they are delivered to the sewers.

Sewage also contains considerable vegetable tissue which is rejected (as in the preparation of food) without passing through an animal body. Its constituents and its destiny, however, are similar to those of the animal rejecta. Both are equally capable of causing offence or fostering disease.

In the conservation of matter, as of energy, nothing is ever lost. When a bit of organic structure passes from under the preserving control of the vital force, it must be demolished, and the materials of which it was built must be returned to nature's storehouse for further use. There is thus a constant, circling, interchange between the three physical kingdoms—animal, vegetable and mineral. If it were not so the supply of plant-food would soon be exhausted, and life would perish, buried in its own refuse.

There is but one way in which organic matter can be disintegrated—by combustion. The ashes and gases which result from the combustion of animal or vegetable matter are no longer organic, but mineral. Combustion, which is but another name for oxidation, is of three kinds: Igneous, which we call fire; chemical, which is illustrated by the rusting of iron; and bacterial, which is commonly known as decay. The first can attack either mineral or organic matter. It is of little or no use in the treatment of sewage, for the one part in a thousand which we wish to destroy cannot be touched effectively by fire until the 998 parts of accompanying water have been evaporated. The second, chemical oxidation, attacks mineral matter only, save in a very limited degree. It is of no value in sewage treatment. The third, bacterial oxidation, is the means which nature has provided for the demolition of dead animal and vegetable tissue and the preparation of plant food.

Bacteria, as we all know, are minute living organisms, invisible as individuals, yet so numerous and so active as to balance the energy of all the constructive forces of the world. They are universally present in water, in the air, in the soil, and in our bodies. They have been at work ceaselessly since the first death of the simplest vegetable growth. Since the beginning of history they have disintegrated and returned to the soil a mass of human excreta, which alone would equal 178,000 pounds for each square foot of the earth's surface, to say nothing of the wastes of all other forms of animal life, and the enormous masses of dead vegetation. Manifestly, without their aid, existence would be impossible.

In the popular mind the word "bacteria" still calls up unpleasant pictures of dirt and sickness. The sensational press fosters this feeling, and keeps its readers nervous with tales—and sometimes with astounding pictures—of bacteria in bank notes, on car straps, in carpets and curtains. Patent-medicine vendors advertise their "microbe-killers," which fortunately are not so inimical to the welfare of mankind as their names would indicate. The truth is there are as many kinds of bacteria as there are kinds of men. Some few are known as the stimuli of certain specific diseases, but the vast majority are beneficent. The percentage of hostile forms is lower than the percentage of criminals in the total population; and no greater than the percentage of poisonous plants in the flora of the country. Wholesale germicide, because of the sins of the pathogenic individual bacterium, is as unjustifiable as wholesale homicide, because a criminal happens to be also a man.

There are many varieties of filth-destroying bacteria. Some of them work best without air; some are indifferent as to whether air be supplied or not; and to others air is a vital necessity. Those of the first class are more violent in their action than the others. Properly controlled, they are extremely useful, especially because they are able to break up and liquefy organic solids; but their activities must be directed and curtailed, for they belong to the class from which the criminal, disease-producing bacteria are recruited, and their products, if they are allowed unlimited sway, are foul and disgusting. They are the agents of *putrefaction*.

The air-loving bacteria, on the other hand, work without offence, and complete the mineralization of organic matter by combining its elements with oxygen. A familiar example of their action is the inoffensive decay and disappearance of the dead leaves in a forest. They are the agents of *decomposition*.

The bacterial destruction of filth is not accomplished in a single step. The unraveling of the inter-twisted strands is a complex process. One kind of germ breaks up the carbonaceous matters; another attacks and resolves the albuminoid ammonia; still another *begins* the oxidation of the

free ammonia, but is unable to finish it without the aid of another group. The science of sewage disposal consists in the recognition of the progressive steps of decomposition, and the skilful use of the different groups of decomposing agents in series, so that each, in doing its own part of the work, may prepare the material for effective treatment by the next colony of helpers.

The practical application of these theories is exceedingly simple. The country house-wife who carries a pailful of dish-water to her back-door and flirts it over the grass-plot is practising the art of sewage disposal as sanely and soundly as the expert engineer who devises complicated systems of tanks, airlocks, filters, siphons and the like, and then pump millions of gallons through them daily. The active agents and the successive steps towards purification are identical in both instances. The flirting of the dish-water scatters it, so that it strikes the ground, not in a mass, but in a finely divided condition—a film of inappreciable depth. This brings every part of it into intimate contact with air, and spreads it, more or less evenly, over a considerable area of purifying earth. The small solid particles of grease, food-refuse or free soap remain upon the surface, to be slowly oxidized by the bacteria which inhabit it, while the clarified water leaches away into the soil, running the gauntlet of untold myriads of organisms, which ransack every drop in search for food. Before it has gone very far, the water is practically pure; and a little later the retained solids have disappeared, passing off as carbonic acid, water, atmospheric nitrogen or oxidized nitrogen.

These conditions may be maintained indefinitely, if the water be not thrown too often in the same place. After each application, ample time must be allowed for the disappearance of all dampness, in order that air may penetrate the pores of the soil, supplying oxygen needed for chemical combination, and stimulating the air-loving bacteria. If the ground be allowed to become sodden, the air will be excluded from the soil, and putrefactive processes will speedily assert themselves.

This is the sum and substance of broad irrigation, which

has been used, on a large scale, for many years with excellent results by Berlin, Paris and many other large cities. It requires a large area of porous, well-drained land; but, with this given, the cost of preparation is little and operating expenses light. If properly designed and cared for, the installation is permanent. We have in this country no fields commensurate in size or age with many in Europe; but we have excellent examples, on a small scale, of this method of disposal.

Where a sufficient area of suitable land, at a reasonable price, cannot be found, some steps must be taken to concentrate and intensify the purifying process, so that the same results may be obtained more quickly and in less space.

The first step made in this direction was the development of the process known as Intermittent Downward Filtration. This differs from irrigation only in that it employs a filtering medium so exceedingly porous and well drained that air can follow the descending sewage to a considerable depth. The zone of purification is thus extended downward and the capacity of a given area greatly increased. Occasionally beds of natural sand are found admirably suited for intermittent filtration; but any porous material will answer—gravel, broken stone, burnt clay, coke, coal, slag or shells. The purification depends, not upon mechanical straining out of impurities—though the word “filtration” might seem to indicate this, but upon the detention of the sewage, for a sufficient period, within a medium colonized with the purifying organisms and thoroughly aerated from time to time.

One common type of intermittent filter, known as the “contact bed,” devised by W. J. Dibdin, late Chemist of the London County Council and Metropolitan Board of Works, consists of a pit (often a simple excavation in earth, but preferably lined with concrete or other masonry) filled with some coarse-grained substance like broken stone, coke, slag clinker, or even cinders—though the last named are hardly suitable because of their tendency to disintegrate. Each “unit” consists of a number of these beds—usually four or five—which are filled in turn, allowed to stand full for a while and then drained.

While the beds are standing full of stagnant sewage air is, of course, excluded, and oxidation is limited by the amount of oxygen *stored* in the bed or derived from the sewage itself. As the liquid subsides, air follows into the interstices of the filter and aerobic bacterial action is stimulated, sweetening the mass and storing a measure of oxygen for use in the next filling. The beds are filled and emptied (usually) but two or three times a day and the oxygen inhaled at each draining is but one-fifth the atmospheric contents of the voids, a trifling quantity as compared with the amount needed for the complete combustion of the impurities delivered to the bed. From the standpoint of bacterial economy the principle of operation is defective, for the different groups of bacteria, which should work separately and in sequence, are here huddled together, tenement-house fashion, regardless of their various needs and their mutual antagonisms. The nitrifying agents, which require abundant oxygen, and a food predigested to the point marked by the formation of nitrites, are periodically drowned by a sewage devoid of oxygen and strong in ammonias. As a result the purifying bacteria never attain the highest efficiency. The results are similar to those which would follow the labors of a farmer who stirred together oats, corn, clover, buckwheat and rye, and sowed the mixture broadcast.

For a while this contact-bed system enjoyed great popularity; but its shortcomings have been recognized, and at a recent meeting of eminent English engineers, the consensus of experience showed that "contact beds had not reached the high standard of purification which was once expected."

Far better is the type of filter drained at the bottom by an outlet never closed, and fed with sewage which comes into contact with all the surfaces of the filtering material without interfering with free aeration of the mass. The sewage evenly distributed at the top is never at rest, but is continually moving through the bed and always in one direction, so that each successive stratum becomes the abode of bacteria of a certain family, which are fed uniformly with food suited to their needs and which pass on, to the next group in the sequence, exactly the pabulum

required for its sustenance. To carry out the simile, the oats, corn, clover, buckwheat and rye are now sown each in its own field, and the results are vastly better.

In 1894, it occurred to the late Colonel Waring that absorption of oxygen from the air was a somewhat slow process and that forced aeration of the filtering medium might hasten materially the work of purification. He accordingly established an experimental plant at Newport. Sewage from the main sewer was pumped into a series of tanks. These were filled, respectively, with coarse broken stone, fine broken stone, pebbles, quartz-gravel and coke; and an air-pipe, descending to the bottom of each, introduced a constant blast from a fan-blower. Three of the tanks were operated intermittently, and two of them continuously. In the latter, the flow trickled down in thin films over the particles of filtering material, while a blast from the blower rose continually through the voids between these particles. The results were unexpectedly good, and the effluent was much purer than the Newport city water supply. It was collected in a square wooden tank, and in this we kept live fish. Since then the system has been introduced in many places. This system combines the maximum of purification with the minimum of land requirement. An area 8 feet square will purify 1,000 gallons of sewage a day. The operation of these filters involves the expense of running a fan-blower; but this is inconsiderable, especially if electric power, which needs little attention, be used.

All of the processes thus far described are based upon the theory that putrefactive action is to be avoided and decomposition alone employed. Indeed, until very recently, this theory was the very spinal column of the science of sewage disposal. A few years ago appeared what seemed to be a reversion to an old type—the septic tank, which has been called a “glorified cesspool.” It was remembered that the old cesspools seemed to have a marvelous way of receiving, without any serious accumulation, solids amounting in volume to many times their own cubic capacity. This was well known but not understood. Investigation showed that many of the putrefactive bacteria have the power of lique-

fying organic solids. As these solids have always been more or less difficult to treat, the attempt was made to employ these useful but reprehensible bacteria, and it succeeded. Liquefaction, by anaerobic organisms, is to-day the cheapest and best means of treating the solids of sewage. Moreover, if properly controlled, the process is an admirable preparation for the subsequent oxidation of the dissolved impurities in aerated filters.

In its simplest form the septic tank, or digestion tank, as I prefer to call it, is simply a reservoir, with a capacity equal to the average flow of say twelve hours. The sewage, entering at one end, loses its velocity immediately, and its heavier suspended solids begin to sink, while the lighter rise to the top as scum. This separation of solids and liquid continues until practically all the suspended matter is eliminated. The clarified liquor then escapes gently at the far end of the tank from a plane between the sludge and the scum. This action continues from day to day, the solids accumulating until those which were first deposited, and attacked by the bacteria which colonize the tank, have become liquefied, passing out with the escaping effluent. Thereafter the rate of accumulation is exceedingly slow, for the process of liquefaction offsets the entrance of new solids.

The septic tank, however, must be carefully designed and carefully controlled. The capacity of the tank must be adapted to the volume of flow and means of adjustment provided. Depth must be sufficient to admit of ample sludge-storage and scum-formation, without encroaching upon the section of flow needed for complete subsidence. The current must be effectively checked at the very inlet and a distribution made that will secure the use of the whole cross-section of the tank; otherwise the sewage will pass through rapidly in stream lines while the sides or corners retain indefinitely festering accumulations. The clarified liquid must be withdrawn from the whole width of the tank in such a way that there shall be no considerable increase of velocity at the outlet. Means must be provided for the removal of silt without disturbing the general deposit of

sludge. Light must be excluded; an even temperature must be maintained. The superficial area of walls available for colonization must be the maximum compatible with uninterrupted sectional flow. It is now believed best to construct a tank so that the velocity of flow will constantly diminish, thus securing a classification of the deposited solids. These, and other details with which I shall not burden you, must all be considered in designing a digestion tank.

The effluent from a tank of this kind is not pure by any means. It still contains practically all its original dissolved impurities, though their organic structure has been so shaken and loosened that subsequent purification by any of the processes already described is easy.

Realizing that, in many cases, high concentration of treatment is necessary, and yet the expense of running a blower almost if not quite prohibitive, an attempt was made some years ago to design a high-rate filter through which the sewage would pump its own air. This was successfully accomplished, and the "wave-bed" system is now in satisfactory operation in several towns. Each unit of a wave-filter consists of a long narrow bed, laid on a rather steep slope, preferably walled with masonry and floored with concrete, and filled to a depth of from 1 foot to 18 inches with crushed coke.

This coke is covered with a few inches of broken stone: (1) to hold down the lighter material and prevent washing, (2) to exclude the light, (3) to assist in maintaining an even temperature, (4) to hinder the theft of the coke for fuel, and (5) to present a slightly and uniform surface. The sewage never wets the stone, which always looks as though fresh from the crusher.

The liquid is fed to the head of each wave-bed intermittently, in measured doses, by a siphon, which delivers it faster than the coke can pass it.

By the time the flow of the siphon ceases, a head of water, equal to the depth of the coke, has accumulated at the upper end of the bed; and this passes down through the coke as a wave, flattening somewhat as it goes, but re-

taining its wave form until the bottom of the bed is reached. As the liquid travels through the coke, it drives out ahead of it all the exhausted air and gases of decomposition, and draws in behind it an equal measure of fresh air from the atmosphere. The bed is, in fact, a coke filter 100 feet deep (though laid on its side), no part of which is more than 18 inches away from the free atmosphere; and each succeeding wave pumps fresh air through its entire depth.

The passage of the liquid is so rapid that the purification is not so complete as in the forced aeration system; but it is amply good for all purposes save discharge into a drinking water supply. Our average results run from 84 to 93 per cent. of purification. Analyses made by the Ohio State Board of Health showed that the plant at Kenton accomplished over 94 per cent. of purification. A peculiar and admirable feature of this system is the oxygenation of the effluent to the point of saturation.

The success of either the contact-bed or the various forms of streaming filter depends largely upon the distribution of the sewage. The best method of distribution is undoubtedly hand-control; for the most ingenious mechanism cannot exercise judgment or perform its cycle of operation with the elasticity needed to meet perfectly conditions constantly varying. But hand-control is expensive, and elasticity of operation easily degenerates into irregularity of operation. So that it is usually wiser to trust an unsalaried, uncompromising mechanical device in preference to expensive human fallibility. Many complex arrangements of valves, floats, weights, gears, etc., have been devised; but all of these involve the employment of moving parts, and moving parts mean friction, wear, frequent inspection and attention and eventual renewal. Better, in my judgment, is distribution by means of siphons, airlocks and kindred devices, which consist solely of castings and piping firmly built into solid masonry and without valves or other moving parts. In mechanism of this class, the flow is controlled by air alone, and the air is transferred from one part of the apparatus to another, or released entirely by the rise and fall of the sewage in the several beds. By the automatic airlock device,

sewage can be fed, in sequence, to any number of filters, and any filter once filled can be emptied after any determined interval. Moreover, any filter, or group of filters, may be cut out of the cycle, and the others will continue to operate in rotation. So long as there is sewage to be treated, the actuating power is present, and so long as the atmosphere rests upon the earth, the transmitting agent is ready to do its work. The castings and pipes, if properly painted, will last a generation.

Before closing I wish to say a word or two about the subject of location for sewage disposal works.

Fortunately, topographical conditions usually lead to location in a portion of the community low-lying, and therefore least desirable for residence. But if the works be well-planned, carefully built and *properly operated* there is no *hygienic* reason why they may not be placed in any convenient location.

If a sewage-disposal plant proves offensive, one of two things is certainly true—either the plant is defective or, what is more likely, the system is not cared for properly. The latter trouble is not uncommon, and it is usually due to a resurgence of the barbaric instinct that tries to throw away, without expense, what it does not want. I know of one town that built an excellent modern disposal plant, and then refused to vote \$15 a month for its maintenance.

But, no matter what site is chosen, or how excellent the plant and how careful the attention given it, objections are to be expected—either from those who are willing to hinder public improvements by levying more or less open blackmail, or from those sincere, well-meaning folk who are governed by ill-founded fears or misguided sentiment. The fears may be banished by the exhibition of a single good plant; but the sentiment cannot always be dealt with so easily. No man cares to have his neighbors locate his house by saying: "He lives just across the street from the disposal works." But sentiment may be educated. One town not far from Philadelphia turned the landscape gardener loose on its disposal field. With stone walls he trained the brook in the way it should go; he built rustic bridges; he laid

out paths, roads and flower beds; he graded, terraced and sodded. The grass is neatly trimmed, the paths are clean and well kept, and the tract is called frankly The Sewage Park. The entire town is proud of it, and with reason.

The surest index of a community's progress is the treatment accorded to its wastes. Wise is the man who recognizes the evils that threaten him, and takes efficient measures to avert them; but nobler is he who sees in threatening evil the possibility of future good; who knows that in things material as well as spiritual death is followed by resurrection.

Not long since I visited a town to inspect a sewage disposal plant of great interest. I was a stranger without a guide, but I followed the valleys of natural drainage, and these led me unerringly to the works I sought. As I stood on the road at the foot of the town, I saw in the valley below me a long roof which looked as though it might cover the sewage tank. Leaning on a gate near-by stood an old farmer, evidently a Scotchman, whose shrewd but kindly face betokened an interest in my movements. To make sure before descending that I was on the right track, I asked him if he could tell me for what purpose that long, low building was used. He sized me up for a moment before replying, and then said slowly: "It's full of unborn grass and flowers and fruit for God's garden." It was the best definition of sewage I had ever heard.

NOTE.—Mr. Hill exhibited lantern slides illustrating sewage disposal works at Rochester, Brooklyn, Napanoch and Depew, N. Y.; Willow Grove and Rosemont, Pa.; East Cleveland and Kenton, O.; Collingwood, N. J., etc., and described the various methods of construction employed.

A DIVISION OF TESTS ESTABLISHED BY THE SECRETARY OF AGRICULTURE.

The following special order has been issued by Secretary Wilson, of the U. S. Department of Agriculture, viz. :

It is hereby ordered, That there be, and there is hereby, established in the Bureau of Chemistry of the United States Department of Agriculture a Division to be known as the Division of Tests. The work of this Division shall be to test and investigate road materials and all materials of construction relating to agriculture, and to do collaborative work provided by law with other Departments which may require such assistance from the Secretary of Agriculture. This order is to take effect July 1, 1904.