SEWAGE WORKS JOURNAL

Vol. XVI JULY, 1944 No. 4

Special Features

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Effect of War on Sewage Treatment Chemicals—Symposium

Effect of Metal Plating Wastes on Activated Sludge—

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Fifth Annual Meeting—Oct. 12-14, 1944
Hotel William Penn, Pittsburgh, Pa.

OFFICIAL PUBLICATION OF THE

FEDERATION OF SEWAGE WORKS ASSOCIATIONS

Announcing—

The Fifth Annual Meeting

OF THE

Federation of Sewage Works Associations

IN CONJUNCTION WITH

The Pennsylvania Sewage Works Association

Hotel William Penn

Pittsburgh, Pa.

October 12-14, 1944

Federation of Sewage Works Associations

325 Illinois Building Champaign, Illinois

SEWAGE WORKS JOURNAL

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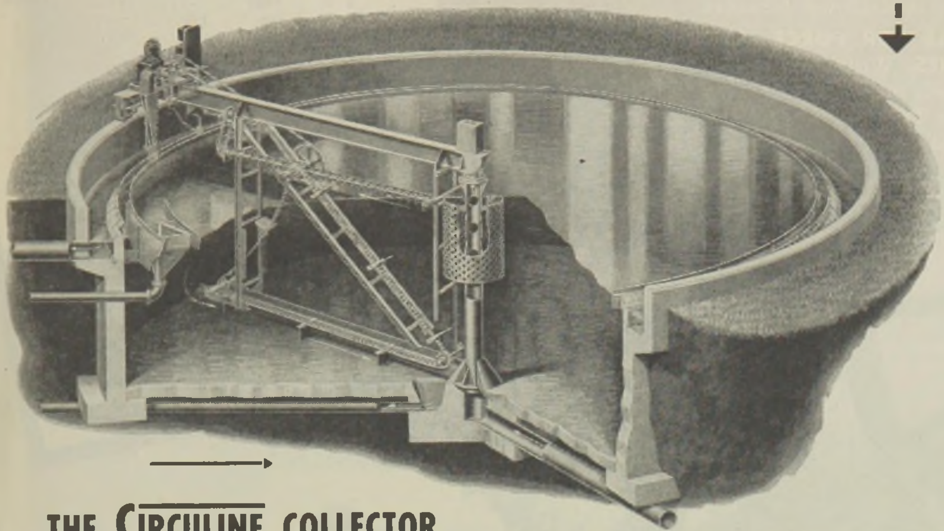

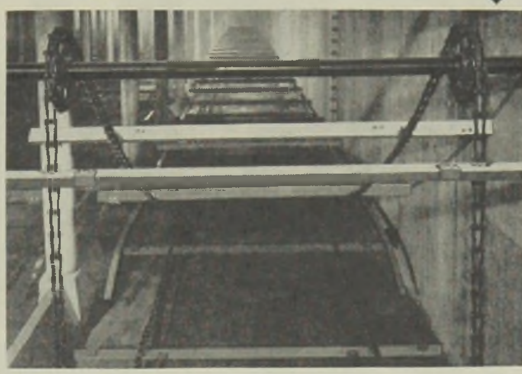

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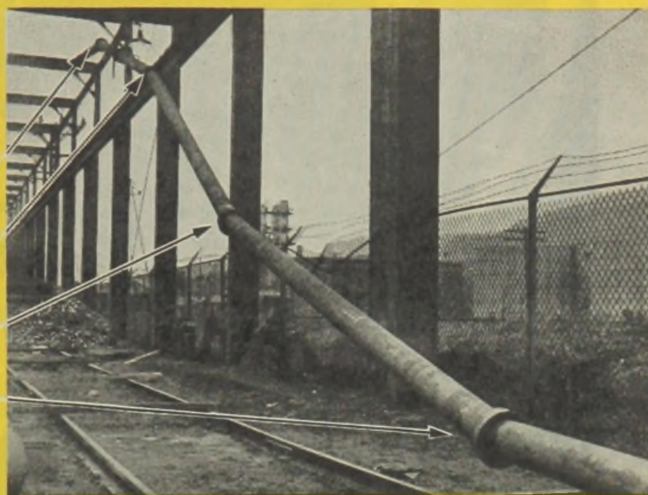

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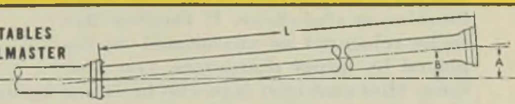

Size	Maximum Safe Deflection			Permissible Deflection for Joint Assembly		
	Angle B	Distance A		Angle B	Distance A	
		L = 16′	L = 18′		L = 16′	L = 18′
3″	9° 0′	30⅜″	34¼″	5° 30′	18½″	20¾″
4″	8° 30′	28⅝″	32¼″	5° 10′	17¾″	19½″
6″	8° 0′	26⅞″	30¼″	5° 0′	16⅞″	18⅞″
8″	7° 0′	23⅝″	26½″	5° 0′	16⅞″	18⅞″
10″	6° 30′	21⅞″	24½″	4° 30′	15⅛″	17″
12″	6° 0′	20¼″	22¾″	4° 30′	15⅛″	17″
16″	5° 0′	16⅞″	18⅞″	4° 0′	13½″	15⅛″

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Sewage Research:

Sewage Works Design:

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Editorials:

Proceedings of Member Associations:

Reviews and Abstracts:

Plant Operation

POSTWAR AND ADVANCE PLANNING—A SYMPOSIUM *

BLUEPRINT NOW! WHO STARTS IT?

By E. L. Filby

Field Director, Committee on Water and Sewage Works Development

On the train through Texas, conversation developed with a service man who rather glumly stated he was "going home." He had no job in sight and because of a medical discharge he was worried about what he could do when he arrived there. He is but one of 80,000 men now returning home from the war every month—to become cogs in our civilian economy once more.

What are our obligations to these men and women? What can the local city government do to aid them? Yes, to speed them on their way to self-supporting and self-respecting work?

Our present day veteran's problem is a light one but this makes the present transition period an important "breathing spell" in which to check policies and blueprinting programs for use in the peak load postwar period. The time to plan—and organize—is *NOW*. It is necessary to start *NOW* or we will have too little ready too late.

Sewerage and sewage treatment will occupy an important part in municipal public works construction for the postwar period. It is one of the key undertakings that can be put under construction promptly. In a study of the National Resources Planning Board, it is revealed that the average elapsed time between award of contracts and start of construction work was: in winter months—57 days; in frost-free months—30 days, and the best all-weather construction possibility, solely from this angle was—sewage collection and treatment facilities! So the field of sewage disposal is attractive from a "speedy action" angle.

Do we need to consider the needs of sewage treatment? Certainly to this group the needs are self-evident. But there are still communities, villages and cities which consider that if they discharge into some water course beyond the city limits, they have done all that is necessary. Or, if the state department of health has the intestinal fortitude to say *NO* and require treatment—then what is the minimum amount of treatment they can "get by" with? Industry, likewise, generally looks upon waste treatment as a stepchild to be ignored if at all possible or to be dealt with only if they are forced to do so. Fortunately, these attitudes are changing and the seeds of good housekeeping, planted years ago by

* Presented at 29th Annual Meeting, New Jersey Sewage Works Association, Trenton, March 23–24, 1944.

the state departments of health and water policy commissions, are now sturdy trees beginning to bear fruit. Cities and industry are more mindful of the local "good neighbor" policy and they are respecting the rights of others. Streams must be kept clean and suitable for normal industrial use. Public water supply sources must be kept as free from pollution as is humanly possible and treatment provided to prevent water-borne disease or to condition (soften or decolorize) the supply.

Sewers and sewage treatment plants (especially that important part of the plant—the bypass) are often the chief sources of contamination of our streams. Many plants are old and need modernization or reconstruction; many are overloaded and can only handle part of the load; many are rapidly approaching a stage where operating costs indicate replacement of inefficient units. And, who is the person who best knows the local problems? It is indeed the operator—the plant superintendent. It is he who should start the *BLUEPRINT NOW* program—he must "carry the ball" and his "interference" will be "taken out" early in the game if he does not start with a careful, well-considered strategy as to how to win approval of improvements at the plant.

Speaking of interference for our ball carrier, there are two parties of great possibilities. First are our friends, the engineers of the State Department of Health, the University research staff and the Water Policy Commission. These men have the overall broad viewpoint of the entire watershed—of which our plant is but a component. They are also alert to potential development of the watershed, stream utilization, process modifications, etc. Moreover, by repeated inspections, observations and testing, they are keen analysts of plant performance and "tricks of the trade." Their help or "interference" is excellent and their police powers may "take out" that last obstruction before we reach our goal. The other "blocking back" is that purveyor of good cheer and an exceptional product, our friend the sales representative. In these days, he is often a technically trained engineer who knows many of the whys and wherefores of his product—and many times that of his competitors! His friendly consultation and advice are often invaluable in evaluating advertising claims. His suggestions are usually worth investigating and I bespeak consideration for him. We in consulting engineering work have long since learned to appreciate the contributions to the art made by the men in health departments and sales organizations.

First, the plant superintendent should know the needs of the plant—what type of effluent need be produced to maintain the proper biological balance in the stream below? What sewage flows can be expected to reach the plant and what will be the characteristics of the sewage to be treated? In short, the problem must be analyzed as to the local and regional needs, then the present or proposed plant analyzed to see if it can meet these needs, and still further, meet them economically and without creating a nuisance. If it cannot, as evidenced by personal experience backed by official records or general knowledge of the plant process results, what are the discrepancies? What are the weak points? Where should expenditures be made that will give the most good for the least expenditure? Additional sludge digesters, more filters, better primary treatment, perhaps an entire new plant—these questions must be answered first of all.

Second, the superintendent should apply ''priorities'' to the needed improvements. This item is a *must.* This one is necessary. That one is desirable. This is a ''well, I'd-like-to-have-it-but-can-get-along-without-it.'' When you are through, your projects will be catalogued and classified and you can put your finger on what is truly needed. And now that we know what is needed, how to get it?

We must plan to present our plea for action on the part of ''the powers that be'' so that they cannot shrug it off with a ''we'll do that next year'' or ''people can't see a sewer system.'' It is true that there is little glamour attached to collecting and disposal of the wastes of man but it is perhaps the reason why American cities are not like the pest holes of India and the teeming hovels of China. Water and sewers have made cities safe places in which to live. The moral and legal rights of our downstream neighbors must be known, the threat of damage suit litigation must be understood, the problems of disease transmission recognized. And with American boys returning from the Orient, Malaya, and other tropical areas we will have the water-borne diseases of the ancient civilization to contend with—dysentery, cholera and other tropical intestinal infections. We must know *WHY* a sewerage system is needed. We must know *WHY* a sewage treatment plant is necessary. We must know *WHY* improvements are mandatory.

It is reasonable to expect that an alert superintendent can, after due thought, give adequate and just reasons to substantiate his thesis. But there is one big reason and that is to provide jobs for the returning veterans—jobs that will give Johnny and Joe a chance to adjust again their tempo of life to that of their old home town. A chance for them to earn a modest living and to retain their self-respect—a chance to ''reset their sails'' on the course of life to come. You can give them this chance by *BLUEPRINTING NOW* the needed betterments and improvements. You can feel mighty proud if you have the plans and specifications ready for construction contracts that will put hundreds of men to work, locally and back in the factories. Sewers and sewage treatment works offer a variety of jobs, all the way from the unskilled ditch bottom shaper to the highly skilled electrician and steam fitter. Bricklayers, tile setters, carpenters, masons, pipe fitters, welders, shovel operators, concrete mixers, form builders, steel setters, erectors, moulders, painters and many more crafts and trades are gainfully employed on this type of work. Engineers, foremen, time keepers, bookkeepers —all fit into the picture. Construction—public works construction—is the bridge that will span the valley of unemployment between the shut down of war goods manufacturing and the resumption of peacetime production. And this public works bridge will have a large segment of sewers and sewage works construction. Of 33 cities reporting in a recent sampling for postwar planning, 15 report sewerage extensions, 4 sewage treatment works and 5 both types of work—24 out of 33 cities—73 per cent. Perhaps it would not be amiss to say that sewers and sewage treatment will constitute the largest postwar municipal construction. Every home sewered and a modern sewage treatment plant is within the reach of every community. If it is planned now, it will provide jobs for the men and women released from war. New Jersey, which had a 1940 peacetime gainful employment of 1,569,000 men and women, may expect some 281,400 veterans and 327,800 industrial workers to be absorbed or 609,200 persons—38.8 per cent of the 1940 gainfully employed! New Jersey has a problem exceeded only in 7 states.

I have omitted the consulting engineer purposely, for he is usually brought into the picture to determine the details of design procedure, cost estimates, specifications, etc. He, or the design department of the city or district, is the fourth member of our "backfield." The signals are being called *NOW*—the state engineers and sales representatives shift into position—the ball is snapped. Mr. Superintendent—it is up to you!

SELLING POSTWAR PLANNING TO THE LOCAL TAXPAYER AND GOVERNING BODY

By Frank D. Livermore

Mayor, Ridgewood, N. J., and Assemblyman, State of New Jersey

My telephone rang late one afternoon and a familiar voice informed me that a few convivial friends were to meet at his home that evening to explore the various phases of human emotions as expressed in the putting together of a few hands of draw poker, with suitable variations, and to the accompaniment of fitting refreshments, and requested my attendance. Not being able to think of a better way to pass the time, I accepted with the comment that my pocket held an assortment of loose change looking for company or a new home. His reply was, "Brother, if you want to sit in on this party, never mind the change, bring some folding money, you may need it." You will be spared the harrowing details as to what happened and how well founded his suggestion was, but suffice to say, without the said folding currency, I would have been all through before the game really got started.

The only reason for my presence here is that I have the very definite impression that a lot of well intentioned people are going to find themselves in the game of postwar activities, but when the cards are dealt all that they can do is "ante" a set of plans and then fold up. This is obviously a poor way to participate in much needed improvements. No one subscribes more wholeheartedly to the idea that fully detailed plans should be prepared and carefully checked and re-checked to avoid the asinine expedients resorted to only a few years ago when all hands were caught napping, but at the same time, no one rebels more at extravagant costs and loose financing than myself. This is no partisan political criticism of what has happened, as I am inclined to think that N.R.A., W.P.A. and what have you, did not have any worse odor or fouler effluent than the Teapot Dome mess of a few years ago. Be that as it may, just remember that when you pay your income tax, you are helping to pay for some of the so-called "free grants" which were dished out for some of the most gosh awful projects ever devised by man, and that one of the ways to stop that is to have real plans for real work ready P.D.Q.

The other way is fully if not more important, and that is a sound financial program. At the risk of bringing a storm of criticism on myself, it is my firm conviction that the more the expenditures are made and controlled by the local governing body, the less the total cost and the more the ultimate fitness and efficiency of the project. I would have no qualms at all in accepting a federal grant of, let us say, 50 per cent of the cost of some major work, provided the job could be done the way we planned it. From past experience, that "provided" isn't as easy as it sounds and it behooves us to examine carefully with a sharp eye whatever agreements may be concocted in the future to cover such grants. When I recall some of the conditions and some of the bosses, supervisors, checkers, time keepers, water boys and would be engineers of days not too long past, the chances of getting something done when and how *you* want it done are about as remote and costly as trying to fill a bobtailed flush in an eight-handed game. Past experience has indicated that the proportion of overhead costs in connection with these so-called grants rises as the construction cost of the project decreases. Therefore, the smaller the job, the worse the headache. If your town is one of the few not enjoying high tax collections and consequently improving its financial status, you had better buy a plentiful supply of aspirin now for you certainly will need it before long. But such instances are so few that they can be omitted in this discussion.

Even under the most favorable circumstances, we must keep this fact definitely in mind—at least half or more of the cost of proposed work must be borne by your own municipality, if a real job is to be done. Along this same line, I do not subscribe to the idea that postwar planned work is merely something to take up unemployment slack, valuable as that is, but rather is something intelligently planned and executed to fill a definite need. It seems to me that this is the soundest basis upon which to sell such a program, and if this be so, what, if anything, have you done or are you going to do in selling the idea to those who are going to pay the bill? Frankly, I see no use in a lot of plans and specifications, no matter how well thought out, unless you match them with the answer to the $64 question, namely, "What are you going to use for money?"

Facing that problem, I know of but one line of approach, first, your governing body and then the public at large. They are the ones who must provide funds by budget appropriations, bond issue or, better yet, setting up a capital reserve right now while the getting is good. Sounds easy, but how do you rate with your powers that be when you really want something? Have you by your own conduct established a cordial feeling of respect for you and the kind of a plant you operate, or have you regarded the Chairman or Commissioner of the Public Works Department as a necessary evil who changes every year or so while you shovel sludge forever, or perhaps as one who rates a sort of professional brush-off whenever he shows up at the plant? There may be some reason for this latter attitude in some towns, but in the main it is not a very tactful way to get money out of him when you need it.

While you are sitting here, let your mind's eye wander around the plant you left behind for the day. What sort of a place is it? Are you glad to have people drop in and look around or does the site resemble a well populated cow pasture? I have seen both kinds and so have you. Now let's stop for a minute and think. How can you expect consideration for yourself and your plans unless heretofore you have taken pains to acquaint those in authority, by personal contact, with the fact that you really know your business and need their help to let your talents accomplish something. Or, put yourself in the position of an official or taxpayer and then ask yourself what you would do toward furnishing funds on a place which looks as if it had been shot at and not missed. How much money would you vote to spend under these conditions? Let me hasten to add that I have the highest respect for the ability, sincerity and devotion to duty of the men in this organization, but every now and then we find some who are so absorbed in their purely technical problems and experiments that they have overlooked entirely their relations with community officials and the public generally. These and all of the rest of you have made outstanding contributions in the field of sewage treatment, but do you just tell it to each other instead of letting others know about it, or do you feel that your work is done so long as your plant functions properly without regard for what the taxpayer knows or thinks about it?

All of these items will be added up when the score is checked for appropriations, and for what good it may be, I should like to offer an experience or two for your consideration.

In our own plant, with which many of you are familiar, I cannot help but have complete reliance in and respect for the opinions of our plant engineer, John Hood, not because of what he says, even when he speaks English instead of that confounded Scotch burr, but rather because of what he has accomplished in a way perfectly visible to the naked eye and the manner in which operating costs appear in the budget. Because of the existing relationship between us, I find it time well spent to visit with him at the plant and discuss fully on the ground those things which we like to regard as our mutual problems. I can even recall a few instances where it seemed entirely fitting and proper to go over matters in my home and occasionally supplementing the discussion with a close view and taste of the dew of the heather plus some soda and ice. What does this mean? Just this. When John presents a set of plans covering what he considers necessary for future work, I am ready to "go to bat" for them. You may ask, "How can you be so sure?" Well, this is the answer.

I have been invited to speak before the Civics Department of our Woman's Club on different occasions and have always supplemented my remarks by extending an invitation to the ladies to inspect our entire Public Works Departments. These include street, park and water as well as sewage and all of them are so operated and kept that they have been a source of amazement to our visitors. The sewage plant is generally our last stop and if you could see the looks of surprise on the faces of most of these women, who incidentally are leaders in thinking in our town, when they find out where they are. You might think they were seeing one of Ripley's believe it or not. Instead of a mess, they see well kept lawns, paved driveways, weeded flower beds and freshly painted buildings. Nine out of ten will stop short and sniff like a well trained pointer, and seem disappointed when they can find nothing to point. They are conducted from one end of the plant to the other and, when they see the effluent, never cease to marvel at what is being done. The net result of this is that a representative group of women of this town know how part of their money is spent and have given it their wholehearted approval, and some have gone so far as to return on their own and bring friends to be shown around. Wouldn't you like to have the backing of a group of this kind for some pet project of yours? If so, what are you doing to get it?

I sincerely believe that most of you are in a good position as regards your public relations, but if you are not, or you feel the need for more intensive public education as to the real value of the fine work you are doing, may I respectfully suggest the following:

(*a*) Check your status first with those who make up your local government. Maybe you will need to adopt some new tactics or polish up the old ones a bit, but most of you have a pretty good line otherwise, so this should not be too much trouble. If you think you need consulting advice, do not be afraid to say so. No one makes too good an impression by pretending to know everything.

(*b*) Get the Commissioner down some day and both of you take a good look around. If the place needs dolling up put it up to him this way. "How can we expect the public to put up money for improvements or new work when this looks as if we did not properly care for what we already have?" It is surprising what a modest expenditure plus some elbow grease and pride can do.

(*c*) If your place is in good order or can be made so, do not be bashful, but extend invitations to service clubs, women's groups, etc., to come and see what they are getting for their money, and, at the same time, be ready to point out what you really could do if given the opportunity and some of that folding money. Don't forget to have the reporter for your local paper on hand, and whatever else you do, sell him a bill of goods. Favorable newspaper publicity costs nothing, except going a little out of your way to be courteous to the press and giving them interesting facts, but pays handsome dividends.

It may be some time before this war is over, so just get busy and do not let all your work and planning come to naught because your taxpayers fail to support the financial end. I sincerely hope you will not be caught in this embarrassing predicament, but will have all that it takes to do the fine things of which you are so capable.

THE EFFECT OF INDUSTRIAL WASTE ON THE TREND OF SEWAGE TREATMENT

By Chester W. Paulus

Mayor, City of New Brunswick, N. J.

Mr. President, members and friends of the New Jersey Sewage Works Association: it is indeed a pleasure and a privilege to be able to present to you my thoughts on the future of industrial waste in relation to sewage treatment.

The Commissioners and myself in the City of New Brunswick have been closely associated with the above-mentioned problem. We have attempted to study the problem thoroughly and we have surrounded ourselves with capable men in the solving of it.

Before getting into my topic I would like to digress for a moment and tell you what a wonderful job you men who operate the sewage treatment plants are doing. I do not believe that enough people are aware of the type of work and the difficulties that you men have to deal with. May I request that you continue your good work. And, may I suggest that your municipal officials be made better acquainted with your problems. Based on the experience in New Brunswick, I am sure that if you do, you will be able to do a better job and you will have more understanding officials.

In the problem confronting New Brunswick, I want to thank the Chief Engineer, Mr. H. P. Croft, and the other members of the Bureau of Engineering of the New Jersey State Department of Health for their splendid help and co-operation.

Although the question of handling industrial wastes and domestic sewage had been thought of in recent years by the New Brunswick city officials, it was not until after we were at war that it came to the fore as a problem requiring serious consideration. Since that time new industries have sprung up and old ones were revived. When this came about, the question arose: "What are we to do with our industrial wastes?"

Before the war, the City of New Brunswick had a small amount of industrial wastes, but after the war started our industries began to boom and our industrial waste problem became a complex one.

To understand the complexity of the problem in New Brunswick we must consider the type of industrial wastes which we are treating. From one industry alone we received some two million gallons of waste a day in volume, equivalent to a sewage contribution from a population of at least 10,000 persons. This waste is sometimes very alkaline and then again very acid. Another industry gives us enough solids at our treatment plant for a community of 200,000 persons, whereas our actual population is but 35,000. There are laundry, dye, dairy, biological, pickling liquors, and many other types of wastes. These wastes complicate the problem in New Brunswick of disposing of the sewage in an adequate and satisfactory manner.

It is my opinion, and this may be repetition, that the officials of every municipality have a twofold duty to perform. One is to see that they co-operate with industry so as to keep them in their municipality and the other is to give the expected "break" to the home owners. Further on in this paper I will point out in detail the manner in which the City of New Brunswick has had the full co-operation of industries. The industries, through an ordinance, will now be paying what we presently believe to be their share in the operation of our treatment plant. The home owners were given the desired consideration and the burden of treating the industrial wastes was taken off their shoulders. I think that with this method of approach, municipalities may be able to hold their present industries as well as acquire new ones.

Thus, with this policy in mind, the Mayor and Commissioners of the City of New Brunswick secured the services of Elson T. Killam, Consulting Engineer, in 1941 and instructed him to make a survey of the sewage treatment plant and present to the Board of Commissioners a program or policy. I would like to summarize Mr. Killam's report as to what he thought would be the best way to handle industrial wastes. He presented three plans:

Plan A.—Independent treatment and complete disposal of wastes by industry with discharge to points other than the municipal system, involving complete separation.

Plan B.—Discharge of wastes into the municipal systems after pretreatment by industry with subsequent treatment at the municipal plant.

Plan C.—Treatment of essentially all wastes at the municipal plant, without pretreatment by industry.

Of these three plans the City officials, upon the recommendation of their engineers, after due consideration among themselves and in conferences with representatives of industries, came to the conclusion that Plan C was the best one for them to adopt. Analyze these plans with me and see why we felt that Plan C was the best.

Under Plan A, the independent treatment and disposal by industries would be the easiest way out for the City, yet we felt it was not the best method. We would thereby increase the actual plant capacity by one-third, but the industries would be individually burdened with a high cost of construction of plants and high maintenance costs, amounting to excessive sums in the aggregate, due to extensive duplication of works and supervision forces. Then again, I am advised by our engineers that individual wastes are often more difficult and costly to treat than a combination of industrial wastes and domestic sewage. Then there is a lack of available and suitable property for individual industrial waste treatment plants. This was another factor which controlled our conclusion in regard to Plan A.

Under Plan B, the discharge of wastes into the municipal system after pretreatment by industry is not a very practicable one for purposes of the City of New Brunswick. Where there is a treatment plant of the biological type and where there are but a few industries, we are advised that this method is the best. If pretreatment meant only neutralization, then all this would mean to the treatment plant is a more uniform quality of raw sewage. Under this plan the municipal plant must handle, not only the original solids in the waste, but all of the chemicals added in the pretreatment processes. Pretreatment by a number of industries in New Brunswick is particularly uneconomical, we concluded, when the wastes of one industry are such that they are neutralizing the wastes of other industries. Another disadvantage of the independent pretreatment units is that each plant must provide a liberal factor for the relatively wide variations which occur at the particular plant. (In other words, excess capacity for detention of flow and for feeding chemicals must be provided.) And, finally, the counter action effect of numerous industries developed by flow through the sewers, through pumping stations, etc., is such that the variation at the main disposal plant is very much less in amount than at the source.

Plan C, that is, the treatment of essentially all the wastes at the municipal plant without pretreatment by industry, has the following advantages, insofar as the Mayor and Board of Commissioners of the City of New Brunswick are concerned:

1. The total cost, disregarding for the moment apportionment between the municipality and the industries, is obviously very much less than the cost of construction and operation of individual plants by each industry.
2. The present municipal plant can handle prevailing flows from both city and industry. With the addition of units involving a cost representing but a fraction of the costs involved for construction in the two previous plans, the plant can be so improved as to handle effectively and economically the entire flow.
3. Some industrial plants are so located that it is impractical to discharge wastes, even after treatment, to any point other than to the municipal sewers.
4. Some wastes offset and neutralize other wastes and cause little trouble in the municipal plant. Certain wastes are actually advantageous in the operation of chemical precipitation.
5. Sites are not available at some industrial plants for extensive disposal works on the plant site, and complicated rearrangement of yard piping and installation of pumps would in many cases be necessary under Plans A and B.

The disadvantages of Plan C are as follows:

1. The high solids content in the industrial wastes greatly overloads the sludge digestion units and vacuum filters and necessitates the installation of additional filters.
2. Solids in industrial wastes increase the cost of operation of sludge filters and disposal of cake.
3. Certain wastes interfere with the efficiency of chlorination and precipitation and add appreciably to the cost of plant operation.
4. Wide variation in quality of raw sewage makes it important to have additional plant units to get good results.

Thus we see that the advantages of handling the industrial wastes at the municipal sewage plant far overshadow the disadvantages. The only disadvantages are the required building of new units and the increased cost of operation, and these two points can easily be taken care of by charging industries for their proportionate share in both operation and capital improvement.

The City of New Brunswick, to accomplish this end, passed an ordinance on February 29, 1944 entitled, "An Ordinance regulating the discharge of industrial wastes into the sewerage system of the City of New Brunswick and prescribing rules, regulations, and schedule of charges for the treatment of industrial wastes." This ordinance is presented herewith:

CITY ORDINANCE

TAKE NOTICE that the following ordinance was adopted on first reading by the Board of Commissioners of the City of New Brunswick, at its meeting held on Tuesday, February 8, 1944. A public hearing on this ordinance will be given to all residents and taxpayers of the City of New Brunswick, at a meeting of the Board of Commissioners of the City of New Brunswick, to be held on Wednesday, February 23, 1944, at the Commissioners Council Chambers, City Hall, 78 Bayard Street, New Brunswick, N. J., at 10 o'clock A. M. Eastern War Time.

AN ORDINANCE REGULATING THE DISCHARGE OF INDUSTRIAL WASTES INTO THE SEWERAGE SYSTEM OF THE CITY OF NEW BRUNSWICK, AND PRESCRIBING RULES, REGULATIONS AND SCHEDULE OF CHARGES FOR THE TREATMENT OF INDUSTRIAL WASTES.

WHEREAS the City of New Brunswick has constructed and operates a municipal sewage treatment plant, together with a system of collecting sewers, pumping stations and appurtenances; and

WHEREAS the municipal plant is in general adequate for a normal domestic sewage load of approximately twice the present population of said City, and

WHEREAS the municipal plant has been and currently is seriously overloaded due to excessive quantities of highly concentrated industrial wastes—to the extent that solids removed—filtered—and hauled to disposal have averaged four or more times the total sludge solids from the entire population of the City; and

WHEREAS the overload created by industrial wastes has greatly increased the cost of operation, maintenance, repairs and depreciation of the municipal plant:

THE BOARD OF COMMISSIONERS OF THE CITY OF NEW BRUNSWICK DO ORDAIN:

1. So far as practicable—industrial wastes may be discharged into the city sewer system—with a minimum of, or without pretreatment, provided the consent of the Board of Commissioners of the City of New Brunswick is first had and obtained; and the rules, regulations and charges herein fixed and prescribed for the treatment of industrial wastes or industrial sewage are complied with.

2. The charges for factory effluents or industrial wastes discharged into the city sewers or tributaries thereof, shall be fixed and determined according to flow, suspended solids and chlorine demand, according to the following schedule of rates:

$22 per million gallons.
$ 5 per ton sludge solids.
$ 5 per 100 lb. chlorine demand.

3. The charges herein fixed shall be payable and billed quarterly on the first days of January, April, July and October of each year, and shall be a lien upon the premises connected with the sewer system until paid.

4. Before factory effluent comprising wastes other than domestic sewage can be discharged into the municipal sewer system, the following rules, regulations and conditions must be complied with:

(*a*) Industries shall at all times co-operate by adopting such schedules of discharge as will, without interfering with factory production—minimize peak concentrations.

(*b*) In the event that the materials, chemicals in, or characteristics of, wastes from any industry, interferes with the efficiency of operation of the municipal plant, or unduly increases the cost thereof, then, said industry shall; by reducing its peak discharges; by construction of equalizing tanks; by partial pretreatment; by elimination of troublesome wastes; or by other approved means; produce wastes of acceptable quality before discharge to the city system.

(*c*) The extent of difficulties and to agree the cost of handling the wastes from one industry may be mitigated or aggravated by wastes from another industry. Accordingly, it is not deemed practical to set at this time, any numerical standards or limitations on concentration or quality. Therefore it is the intention of these rules and regulations to allow maximum latitude in the use of the municipal system—and to require control or special procedure by industry only in such cases as the failure so to do would seriously affect the operation of the municipal plant or would entail unwarranted expenditure at said municipal plant.

5. Measurement of Flow

(*a*) Each industry for which estimated charges will exceed $1,000 per year—shall install a suitable device for continuously recording the flow discharged to the city system. Plans for complete metering installation shall be submitted to the city for approval.

(*b*) In the case of industries for which the total annual charge is estimated to be less than $1,000—the volume of flow used in computing charges shall be based upon metered water consumption.

(*c*) In the event that evidence is presented indicating that more than 20% of the total annual volume of water used for all purposes does not reach the sewer, an estimate will be made of the proper amount to be deducted.

(*d*) Where industries have a private water supply—all or part of which is discharged to the sewer—the amount of such supply or the part thereof discharged to the city system—shall be metered and included in the charges made.

6. Determination of Character and Concentration of Wastes:

(*a*) Means shall be provided at each plant to allow periodic determination of character and concentration of wastes as a basis for charges for sludge solids and chlorine demand. Such determinations will be made at least twice a year; or, if deemed necessary, quarterly, immediately prior to the date of quarterly payments. Determination of character of the wastes will be made by the City and shall be binding as a basis for charges.

(*b*) In the event that the character of the wastes as discharged do not provide representative data as to actual costs—then charges shall be based upon full scale tests at the municipal plant or upon estimates based upon representative data.

(*c*) Samples shall be collected in such manner as to be truly representative of the actual quality of wastes—and standard methods of analysis will be used.

7. Changes and Adjustment of Rates.

(*a*) It is intended that the rates hereinbefore set forth shall become effective as of January 1, 1944, and will prevail until such time as they are found to substantially exceed —or yield substantially less than the actual cost of service rendered.

(*b*) The amounts charged will vary from quarter to quarter with the volume of flow and quality of waste as determined from records, tests, samples and analysis.

(*c*) In the event of changes in requirements of the Department of Health of the State of New Jersey and consequent changes in process and cost, the charges shall be subject to revision.

8. Any person, firm or corporation who shall violate any of the provisions of this ordinance shall be subject to a fine of not exceeding two hundred dollars ($200) or imprisonment for thirty days, or both, in the discretion of the Magistrate; each day that a violation is permitted to exist, shall constitute a separate offense.

9. If any of the provisions of this ordinance or the application of any provision

hereof, to any person or circumstance, shall be held invalid, the validity of the remainder of the ordinance shall not be affected thereby.

10. The term person, includes individual, partnership, association, or any other organized group of persons or legal successors or representatives, if any, of the foregoing.

11. All ordinances or parts of ordinances, rules, or regulations, in conflict with the provisions of this ordinance are hereby repealed.

12. This ordinance shall take effect immediately.

Adopted on first reading, Tuesday, February 8th, 1944.

HERBERT D. DAILEY,
THOMAS G. RADICS,
HARRY W. DWYER,
JAMES T. SHINE,
CHESTER W. PAULUS,
Board of Commissioners of the City of New Brunswick.

Attest:
JOHN F. BOYCE,
City Clerk.
Approved:
PAUL W. EWING,
City Attorney.

The City's next step will be the building of additional units at the treatment plant to be able to handle satisfactorily all the industrial wastes. When the time comes we will decide on a policy as to how the capital improvement charges will be shared by industry.

I believe that if industrialists are willing and do co-operate that most industrial wastes can be handled in adequately designed sewage treatment plants constructed for the treatment of domestic sewage, but, in this co-operation, the industrialists must be prepared to pay their full share of the cost of plant enlargement and plant operation. In expressing such a conclusion, I wish to point out that I am referring to installations that are made to prevent the pollution of waters that injure or may threaten injury to the inhabitants of this State either in their health, comfort or property. This is not intended to apply to installations discharging into streams used for public, potable water supplies.

THE CONSULTING ENGINEER IN ADVANCED PLANNING

By ELSON T. KILLAM

Hydraulic and Sanitary Engineer, New York City

The gap between construction of military and defense facilities and the resumption of normal or accelerated postwar programs for improvement or extension of municipal utilities, provides an unusual opportunity for thorough, sound, and highly advantageous investigation and planning. There is no substitute for thorough investigation—and the cost thereof is invariably but a fraction of the consequent savings.

All too frequently no steps are taken until works are scheduled for immediate construction, whereupon there is a mad rush for plans, specifications and completion of construction—all under pressure.

Limited Time Available for Planning During the Last Decade

Advantageous procedure for postwar planning may be emphasized by reference to difficulties attending planning in past years. We have passed through two consecutive periods in the last decade during which high-pressure planning has been the general rule.

First there was the era of Federal grants, with emphasis on creation of maximum man hours of work at the earliest possible moment. Projects were hastily set up to meet deadlines of weeks, days, or hours, in a race to secure "grants" before some other group obtained the money first. Time schedules were, in general, optimistic, to say the least.

Probably one of the greater compensations for this unnatural stimulus and the supercharged, and often times wasteful era, was the development of high speed planning, subsequently made essential by emergency wartime needs.

In the period which followed, the deadline changed from a race for funds to the essential necessity for providing facilities for the armed services and defense industries, often in a period of weeks. In this later period the time element was of such importance that the contractor often moved in simultaneously with the engineers and architects.

The development of basic designs by telephone conversation; premature decisions on fundamental questions; approval of plans after—not before construction—and quantity production of plans and specifications represent procedures which may be necessary in extreme emergencies, and these practices have resulted in notable achievement of time saving and volume production.

The results attained, however, do not meet adequate standards for municipal utilities which must be operated and must serve for many years. While cost of operating and maintenance is unimportant for works which, it is hoped, will be used for only a few years, such costs often comprise the main item of total annual expense of municipal plants. The selection of type of treatment, source of supply, plant location, and many other basic features of sewerage and water supply works can be most advantageously planned only by complete investigations and extended and laborious studies of numerous alternatives.

Sanitary sewers and storm drains should not be undertaken until a comprehensive plan for entire areas has been established. It is well to remember that the all important decision as to plant location and type of facilities will commit the municipality to a limited course of procedure for many years. Also, that the sanitary sewer being laid today must often serve the community for 50 or 100 years or more. To those interested in construction of water and sewer systems, the frequency of piecemeal planning is incomprehensible. Many instances could be enumerated where lack of comprehensive planning has resulted in wasted expenditures amounting to 10 or more times the cost of planning.

Storm sewer systems built street by street invariably involve duplication, waste, and inadequate performance. In one instance a municipality, which will ultimately construct 30 miles of sewers, constructed less than 1/2 mile of sewer as a first step, in a rush to serve a defense plant. Within a year a second plant in the same general area required service. It was found that the most advantageous route ran parallel to the original line for approximately 1/3 of its length. Because of the elevation thereof, the original line could not be used, and a duplication involving a waste of several thousand dollars was the price of lack of comprehensive planning even before the first mile of the ultimate system had been constructed.

A well supply constructed in advance of investigation resulted in a waste of several hundred thousand dollars, whereas a subsequent thorough investigation resulted in procurement of an adequate supply for a fraction of the original cost.

Far too many treatment plants must be saddled with uneconomical, awkward and otherwise unsatisfactory units due to inadequate comprehensive planning. At the time a plant is designed, 15 years seems far in the future—it is not long in retrospect.

In planning for the future, every municipality may advantageously consider a long range plan, carefully developed to serve requirements for many years in the future. This does not involve excessive expenditure, as improvements and extensions can ordinarily be set up in stages or steps, and work may be undertaken only as required. Under such a plan each stage would comprise a co-ordinated part of the whole.

Local Records

One of the fundamental phases of investigation is local data. There is no substitute for adequate records of sewage flow, stream flow, water consumption, sewage quality, plant performance, and other pertinent and vitally important data. Economical planning frequently requires long term data on stream flow, rainfall, tidal ranges or other conditions. If we wait until plans are required, it is frequently necessary to improvise or guess about highly important data.

This work may most advantageously be done by municipal or operating forces. Such data are of great value for future planning and design, and adequate personnel and facilities should be provided to maintain such records. Work which may at the time seem tedious will ultimately be found to be of great value.

It is hard to imagine any factory or business that does not know "how much" or "how many" are produced or sold—regardless of the size of the enterprise—yet there are plants involving expenditure of tens of thousands of dollars annually, some of which do not have adequate meters. In other cases, meters are allowed to remain out of service for long periods.

Where local data involve other than routine operation, as in the case of stream pollution surveys, engineers specializing in the field can, with a small contribution of time, make helpful suggestions as to scope and methods of procurement of such data to the end that the work may be confined to essentials and nevertheless be adequate. During many of the hurriedly organized surveys of the middle thirties, hundreds of man hours were spent on sewer surveys producing plans without elevations; industrial waste analyses without flow measurements; and other time consuming projects, the value of which was greatly discounted through inadequate direction.

In summarizing this brief discussion—mention should be made of the following factors:

1. It is to be hoped that prevailing practices in the last decade will not be necessary and will not become habitual but that the more ''old fashioned'' and complete investigations will again be the rule.

2. Planning should be more comprehensive and long term in scope. Construction, not planning, should be piecemeal.

3. Municipal officials should provide their engineers and operators with adequate facilities for complete, continuous records and state supervision agencies should be adequately staffed to make complete tests and reports at frequent intervals.

4. The effectiveness of the consulting engineer in postwar planning will be primarily dependent upon the co-operation of municipal officials and their interest in long term planning, to the end that adequate time is made available to the engineer, before the active period of design and construction, to investigate thoroughly and develop a satisfactory plan.

The financial burden imposed by the conditions prevailing during the past decade will necessitate the careful expenditure of funds for utilities, if a substantial part of recognized needs is to be met.

It is, therefore, to be hoped that postwar planning will not comprise a vague process of thinking up the maximum number of projects involving maximum expenditure, but that postwar planning may become an orderly procedure for:

1. Selection, by the process of elimination, of the more essential projects.

2. Selection, by study of the various alternatives, of the most economical and advantageous procedure and method of development.

3. Development of complete designs.

The organization, facilities, and experience of engineers specializing in this field can be made as effective in the development of a long-range policy and plan as in the preparation of plans and specifications.

THE PRACTICAL SIDE OF SAFETY

By Warren D. Wilt

Safety Officer, Department of Water Supply, Detroit, Michigan

Reliable government figures (U. S. Bureau of Labor Statistics) tell us that during normal times approximately 18,000 Americans lose their lives every year owing to industrial accidents—accidents which occur during or in the course of their work. Another 90,000 suffer permanent total or permanent partial disablement due to such relatively minor injuries as partial loss of a finger or stiffened finger joint. Over 1,800,000 more are injured to an extent that incapacitates each from his or her work for more than one day, with a total loss of 30,000,000 man-days of working time. The average duration of such incapacity is 17 days. Putting this loss in a monetary figure we must consider wages lost by the injured worker, overhead cost of insurance, medical expense, and other cost to the employer, called indirect cost. This gives us the staggering figure of $2,700,000,000—enough to buy seven or eight battleships.

The wartime increase in production has made some changes in the overall picture. The nation's industrial fatalities were 53,000, or five times the number of fatalities suffered by the armed forces during the first 14 months of the war.

This wastage of human value constitutes a serious national problem. The killed and injured included a heavy proportion of those having special skills, rare abilities, hard-won knowledge, fine training or valuable experience; many were young people of exceptional promise; the majority were heads of families.

Public utilities accounted for 21,000 of the occupational injuries reported.

Heinrich, in his book *Industrial Accident Prevention,* lists two basic causes of accidents, *i.e.,* personal faults, and mechanical and material faults.

Personal Faults

A. Faulty Instruction
   1. None
   2. Incompleted
   3. Not enforced
   4. Erroneous

B. Inability of Employee
   1. Inexperience
   2. Unskilled
   3. Ignorant
   4. Poor judgment

C. Poor Discipline
   1. Disobedience of rules
   2. Interference by others
   3. Fooling

D. Unsafe Practice
   1. Chance taking
   2. Short cuts
   3. Haste

E. Mentally Unfit
   1. Sluggish or fatigued
   2. Violent temper
   3. Excitability
F. Physically Unfit
   1. Defective
   2. Fatigued
   3. Weak

MECHANICAL AND MATERIAL FAULTS

A. Physical Hazards
   1. Including mechanical, electrical, steam, chemical conditions, etc.
      (*a*) Ineffectively guarded
      (*b*) Unguarded
      (*c*) Unsafe design
B. Poor Housekeeping
   1. Improperly piled or stored material
   2. Congestion
C. Defective Equipment
   1. Miscellaneous material and equipment
   2. Tools
   3. Machines
D. Unsafe Building Conditions
   1. Fire protection
   2. Exits
   3. Floors
   4. Openings
   5. Miscellaneous
E. Improper Working Conditions
   1. Ventilation
   2. Sanitation
   3. Light
F. Improper Planning
   1. Layout of operation
   2. Layout of machinery
   3. Unsafe processes
G. Improper Dress or Apparel
   1. No goggles, gloves, masks, etc.
   2. Unsuitable, long sleeves, high heels, defective, etc.

Another factor, often highly important in appraising the statistical evidence, is that in most cases the wrong act is made glaringly evident by the injury which results. The mechanical fault, however, is seldom so evident and in fact unless a careful, safety-minded study is made of the occurrence, the correctible hazard will often escape notice.

So much for what accidents really are and the great need for an understanding study of each accident with the idea in mind as to how to prevent accidents, save life and suffering, and cut down operating costs. We in Michigan come under the Workmen's Compensation Laws of the State of Michigan which are administered by the Department of Labor and Industry. Any injury to an employee arising out of and in the course of employment is a potential compensation case and may cost the employer as much as $15,750 compensation, plus doctor and legal expense. This is one item we often overlook.

Responsibility of Management

The type and quality of help on the labor market today is far different from that of yesterday. Management has to take these new employees and fit them into their organization the best way possible. The new man does not know your policies or how to do the job assigned the way you want it done. Management's duty is to train the new employee. Giving a new employee a book of rules to read and then taking for granted that he knows all there is to know is folly. The new employee must be shown his duties and introduced to his new surroundings. By doing this you help point out the hazards the new man is apt to find and thereby overcome his fear of doing something wrong, which is in itself a hazard. He will also know the company's policies and what is expected of him. This important part in the new man's employment is ofttimes omitted at the expense of the employer.

There is an estimated ratio that, out of every 330 unsafe acts, 29 will be serious enough to be reported and need medical attention; one will result in a permanent injury, or even death. Supervision cannot be on hand every time one of the 330 unsafe acts is committed, to show the employee the safe way of doing his task, but on his regular tour of the plant he will see part of them. It is his duty to take time to stop and warn the employee of any unsafe practice and show him the safe way of doing it. An employee's one lost-time injury may result from his first violation or from any of the others. It is only in the average case that he is seriously injured in the 330th violation. Look at the hundreds of opportunities that a foreman has to stop unsafe practices before injuries occur.

Statistical data on occupational injuries prior to the widespread passage of workmen's compensation legislation during the period 1910–20 are extremely meager and unreliable. The National Safety Council began to collect and publish figures in 1924 and every year since that time. From the available figures the death toll has been cut nearly in half in the last twenty years. Small plants employing 100 to 500 people constitute a large portion of our industries. We, in the sewage plants, are part of this small-plant picture. All industries have hazards, some more dangerous than others, but when the proper precautions and safety measures are exercised, these hazards become quite harmless.

Cause of Accidents

There is much confusion in the use of the words "cause of accidents." To the preventionist, the cause (or causes) of an accident is the defect or action, or lack of action that should be corrected to prevent a recurrence. The terms usually given as causes do not fit this viewpoint. Usually, handling materials, falls, burns, etc., are listed as accident causes. Actually, handling materials is an activity out of which many accidents come but the cause of each accident is something that some person does or fails to do in connection with the activity in question. Falls lead to injury but the preventionist wants to know what condition, act, or omission led to the fall. Burns are injuries, not causes.

As an aid to a clear understanding, we use, from this point on, the definition of an accident as "any occurrence that interrupts or interferes with the orderly progress of the activity in question." Some accidents (by this definition) involve human injury. Most do not and remain unrecorded except on the cost sheet, for it is obvious that all interruptions and interferences increase costs, whether or not the amount of the cost increase can be measured.

Safety Suggestions

There are mechanical guards and safety measures that we can use to protect the employee and company property, such as guards on belts and pulleys, goggles, shields, etc. In sewage plants where the possibility of combustible gases is always present, care should be taken to guard against static electricity. Care should be taken to see that the proper ground connection be provided on motors and moving parts where there is friction; static collectors or brushes should be placed on belts to remove the static electricity that is generated; electric conveniences, lights, motors and switches made and installed according to approved explosion-proof specifications. It is good practice for employees whose duties take them in and around the digesters to wear rubber or composition sole and heel shoes having no nails in them. Wrenches and hand tools made of beryllium copper metal, a non-sparking material, will reduce the possibility of sparks starting an explosion. Several manufacturers have on the market explosion-proof flash lights. These cost a little more than the non-explosion-proof type but are well constructed and worn out or broken parts can be replaced giving the flashlight a longer life, consequently cutting down the over-all cost.

There are many safety devices on the market which are practical in and around sewage plants. Time will not permit naming each of them. However, I shall call to your attention a few which I think are important. How often have we seen an employee use, or have ourselves used, ladders without safety shoes or boots, or with missing rungs or cracked side pieces. Ropes that are on the market today do not have those good long manila fibers. A rope exposed to chlorine vapors will deteriorate and its strength is greatly reduced. All ropes should be subject to regular inspection before they are taken out of the stock room. To detect flaws in chain links, hooks, castings, etc., saturate them thoroughly with some light oil long enough to permit the oil to soak into any cracks or pinholes, then wipe off all traces of the oil on the surface. After this is done, coat the entire surface with whiting. After the whiting has dried, the oil will begin to appear through it wherever there are deep-seated flaws having surface openings. A blow with a hammer will help bring the oil to the surface. Hooks that have been bent by overloading and later straightened lose their temper and are unsafe to use at their rated capacity.

Hand tools account for 25 per cent of all compensable industrial injuries. The following are a few suggestions and rules governing hand tools.

1. Select the right tool for the job; never use a makeshift.
2. Use only tools in good condition—no cracked or broken handles, none without handles, no tools with mushroomed or broken heads.
3. Sharp tools are safer than dull ones. Keep all keen-edged blades sharp; store them safely when not in use.
4. When using a draw knife, fasten the work in a vise; never brace it with your knee.
5. Avoid using a hammer with hardened face on a highly tempered tool such as a drill, file, die, jig, etc. Chips may fly.
6. Take care to use wrenches the right size for the job. Force the jaws of an adjustable wrench in the direction of the pull.
7. Never apply a wrench to moving machinery; stop the machine, then carefully remove all tools before starting it again.
8. See that pipe wrench jaws are sharp and chains in good condition so they will not slip.
9. Never use any tool in such a way that if the tool slips, it can injure your hand or body.
10. Wear suitable goggles whenever there is possibility of flying objects or harmful substances.

Where necessary, goggles or spectacles should be provided with corrective lenses, otherwise these devices, by impeding vision, may be an added hazard rather than a protection against accidents or ill health. Where ordinary corrective spectacles are worn, the worker may be provided with a ''cover-all'' type goggle that fits over the corrective spectacles.

Masks and hoods are used to protect the face as well as the eyes. Operators working around vacuum filters are subject to sprays of sewage. This is equally hazardous to the mouth as to the eyes. Plastic face shields are comfortable to wear, do not cut down the vision as much as goggles, and give good protection to the face.

One of the difficult problems confronting those interested in industrial health and safety is to convince workers that they should wear some form of eye protection while exposed to flying particles. Eyes can seldom be repaired if injured and their value, of course, is inestimable. No worker wishes to suffer eye injury but the apparent nuisance or inconvenience of eye protectors when first worn tends to cause workers to disregard their value. If a worker is exposed to a potential eye hazard, it justifies the necessity of wearing goggles at all times while on the job.

Rubber gloves should be worn when the hands are exposed to irritating chemicals or other substances that can produce skin infections.

Fire Protection

Proper fire protection increases the safety of employees and expensive, hard-to-obtain equipment. There are six common type fire extinguishers on the market today. Each has its own different use and limitations.

TABLE 1.—*Fire Extinguisher Chart*

Types	Foam	Soda-Acid	Anti-Freeze	Vapor Lq.	Car. Diox.	Dry Powder
Chemical (Obtain charges from manufacturer)	Sol. of aluminum sulphate and bicarbonate of soda with foam agent	Bicarbonate of soda solution and sulphuric acid	Special charges	Carbon tetrachloride with important components	Carbon dioxide	Bicarbonate of soda and other powders
Operating Method	Invert	Invert	Invert or inv. and pump	Pump or open valve	Open valve	Open valve
Extinguishing Effect	Blanketing	Cooling and quenching	Cooling and quenching	Blanketing	Blanketing	Blanketing and sweeping
Protection from Freezing Required	Yes	Yes	No	No	No	No
Types of Fires: Wood, Rubbish, Textiles, Etc.	Yes	Yes	Yes	*	*	*
Types of Fires: Oils, Greases, Paints	Yes	No	No	Yes—blanketing	Yes	Yes
Types of Fires: Live Electrical Equipment	No	No	No	Yes	Yes	Yes

* Of some value for small fires.

Operating forces should be instructed and all fire extinguishers plainly marked as to what purpose they are to be used. In this way, water will not be used on electrical or oil fires and the same for the other types of extinguisher.

First Aid

A suitable first aid station with a capable employee in charge should be established in every plant, first aid to be available twenty-four hours a day, seven days a week. Small cuts or abrasions that are taken care of in time may save expensive doctor bills and lost time later.

Toxic and Combustible Gases

I have saved toxic and combustible gas detection and how to control it until last. This is a big subject in sewage plant operation. First, we shall discuss chlorine gas. Chlorine is a part of the treatment process itself. The handbook on chemical warfare lists chlorine as a war gas. The Michigan Bureau of Industrial Hygiene sets the maximum permissible concentration of chlorine in the atmosphere as one part per million parts of air by volume. Experience has demonstrated to the operator the irritating effect of chlorine on the nose and lungs with the increased difficulty in breathing caused by this gas. Small leaks, difficult to discover, can readily be detected by the use of ammonium swabs or atomizer with ammonium carbonate in it. Chlorine rooms should have forced ventilation with the vent going through a caustic soda wash or to the atmosphere where the wind will not blow chlorine into other areas where damage can be done. Temperatures of the chlorine rooms should be controlled. This will assure better operation of the chlorinators. A gas mask with an ''acid gas'' canister should be kept outside the chlorine room and near the entrance.

Several other dangerous gases may be found in sewage treatment plants—some of which are carried into the plant through the sewers and some of them generated during treatment. The most hazardous of the common gases are hydrogen sulfide, methane, carbon dioxide, carbon monoxide and volatile fumes as from gasoline. When any of these gases are detected in structures, men should not enter until thorough ventilation has been instituted by approved methods and the atmosphere retested. During work, following such retests, portable non-sparking blowers should continue the process of ventilating while work progresses and additional tests made for the presence of harmful gases, or the absence of sufficient oxygen, as the case may be. In emergencies, such as the saving of life, canister masks may be used safely under some conditions as respiratory protection. It is extremely important to realize, however, that canister masks are only suitable for *relatively low concentrations of toxic gases* and that *sufficient oxygen to support life must be present.* If the oxygen deficiency indicator (flame safety lamp) shows insufficient oxygen to support life, a hose mask or self-contained oxygen breathing apparatus must be used. When explosive gases are present, in addition to respiratory protection, it is important to avoid any source of ignition. No open flame should be used, smoking should be banned, non-sparking shoes or rubbers should be worn, non-sparking tools should be used if tools are needed, and all other possibilities of ignition avoided. Explosion-proof electric lanterns and extension lights are required in such cases for illumination. Several vendors have an automatic combustible gas alarm on the market. When the concentration of gas comes to a predetermined concentration, a bell or buzzer sounds an alarm. This predetermined concentration of gas depends on the explosive range of the gas in question. Explosive range refers to the definite limitations of combustibility and rate of burning of flammable gas or vapor mixed with the air. When the particles are so widely separated that those set on fire by the igniting medium will not set fire to others that are nearest, the mixture is called too ''lean'' for combustion and will not burn. When the particles are so close together that they exclude the oxygen necessary for combustion, the mixture is called too ''rich'' and it will not burn. The concentration, or per cent by volume, between the leanest and the richest mixtures that will burn is called the "explosive range." Between these limits will be found various phases of slow or rapid combustion. The principle of the combustible gas alarm is to pass the sample of the atmosphere in question over a preheated element with electric current passing through it. As the sample comes in contact with the hot element, any combustible gas present will be ignited and burn. This burning will raise the resistance in the element. The hotter the element gets, the higher the resistance. This resistance is calculated in percentage of combustible gas present. When the resistance or percentage of combustible gas present reaches the explosive limits of the particular gas in question, an alarm is sounded.

There are also portable explosimeters that operate on this same principle and use batteries for energy.

The flame safety lamp is a gasoline lamp with wire gauge and a glass globe confining the flame to the inside of the lamp. The oxygen required for combustion enters the lamp through the wire gauge which acts as a flame trap. The flame is adjusted to a known height. As the lamp is brought into an area with a deficiency of oxygen, the flame will be lowered; when the oxygen gets as low as 17 per cent, the flame will be extinguished. The presence of a combustible gas will be shown by an elongation of the flame. It is not considered good practice to use the safety lamp where there is a high concentration of combustible gas.

Hydrogen sulfide (H_2S) is one of the most toxic of the more common industrial gases, being harmful in a concentration as low as 0.005 per cent by volume. The concentration may be determined by the use of a hydrogen sulfide detector. Samples of known volume are passed through a tube of powder containing a lead compound. The powder is white in color. The presence of hydrogen sulfide will change this to a dark color or black, according to the concentration. The color change is calibrated in percentage of gas present.

Carbon monoxide (CO) may be detected by a carbon monoxide detector. Samples of known volumes are passed through a tube of white powder called "Hoolomite." When carbon monoxide comes in contact with the "Hoolomite," it changes color. This color change is calibrated in percentage of gas present, on the same principle as the hydrogen sulfide detector.

Mixtures containing abnormally high percentages of carbon dioxide, varying amounts of methane, low percentages of oxygen and sometimes hydrogen sulfide, have been termed by some as "sewer gas." These mixtures sometimes accumulate in sewers as the result of fermentation or decomposition of deposited organic matter.

Care should be taken before entering underground manholes or sumps. A hose should be lowered into the manhole and samples of the air tested for the various gases. Safety ropes should be placed on the employee before he enters the manhole and gas detecting apparatus taken with him as he enters the sewer. Tests are made as he proceeds into the sewer.

Gas Masks

There are three types of mask in common use for protection against combustible and toxic gases:

1. *The Canister Type.*—This has a face piece that cuts off the outside atmosphere. The air breathed into the nostrils comes through a canister filled with chemicals which render any gas in the air harmless or which filter out the gas. As mentioned before, sufficient oxygen must be present to support life. High concentrations of gas will replace the oxygen in the atmosphere and render this type mask useless.
2. *Fresh Air Hose Mask.*—This mask has the same type face piece as the canister type. The source of fresh air is pumped from a gas-free area through a hose to the face piece.
3. *Self-contained Oxygen Breathing Apparatus.*—This type has a similar face piece as the other two. The source of oxygen is supplied from a tank of compressed oxygen carried on the operator's back or chest. The air exhaled by the operator goes through a container of ''cardoxide,'' a chemical that absorbs the carbon dioxide, and this same air is again breathed into the nostrils. The length of time this mask can be worn is limited by the supply of oxygen. They are made with rated capacities of two hours, one hour and one-half hour.

All masks not in service should be thoroughly inspected every thirty to sixty days. The points to observe during inspection are: the condition of the face piece and head band; condition of exhalation valve, connecting tube and canister; seeing that all parts are sound and all connections are tight.

The subject of sewage plant safety is a lengthy one which cannot be covered in such a short period. However, it is hoped that the importance of safety has been brought home to each of us and that the few methods of meeting some of the hazards will prove helpful.

SLUDGE COLLECTION, TREATMENT AND DISPOSAL—A SYMPOSIUM *

SLUDGE COLLECTION AND PUMPING

By David W. Carmichael

Superintendent of Sewage Treatment, Verona, New Jersey

The method of collecting and pumping sewage sludge can mean the difference between a well and efficiently operated sewage treatment plant and one with less efficiency and a multiple of resulting headaches. The general design of the collecting or pumping unit, as the case may be, is not necessarily the fault but rather it is the accumulation of one or several minor details that are either overlooked or must be accepted by the designing engineer.

It is, then, the problem and responsibility of the sewage plant superintendent to make some endeavor to have these problems solved and corrected, not only for the betterment of the plant, but for the benefit of the plant personnel. In this connection, the writer trusts that the operators present will not think him too optimistic.

The collecting units generally referred to as sedimentation tanks, or clarifiers, are various in design and shape, the shape usually being governed by local conditions and the extent of sewage treatment desired. However, all are designed to serve the one major purpose—the removal of settleable solids.

Extensively used today is a greatly improved tank of the early single-story type. Introduction of mechanical equipment for the removal of the settled sludge was designed for use in square, rectangular and round tanks. In this type of tank, the mechanism is designed to scrape the settled solids to a sump at the end of the rectangular tanks and to the center of the square and round tanks, from which the sludge is removed either by gravity or pumping.

It is here, at the point of sludge removal, that difficulty occurs too often. This is an important detail of the tank design and should warrant careful consideration.

In tanks that depend upon gravity and the hydraulic head as a motivating means for sludge withdrawal, care should be given to provide outlet piping of a proper size. Piping too small in size, coupled with short radius bends, does not permit easy flow of the sludge. Stoppages too often occur, necessitating an unpleasant job for the operating personnel. However, this can be partially overcome if the operator maintains a regular pumping schedule, pumping more often for shorter periods of time. Sludge that is permitted to remain in the sedimentation tank too long may become septic, gasify and rise in large pieces to the surface. This is particularly true in the summer months.

*Presented at 29th Annual Meeting, New Jersey Sewage Works Association, Trenton, March 23–24, 1944.

At a plant with which the writer is familiar, the withdrawal problem, caused by an inherent defect in the scraping mechanism which resulted in the sludge piling, was overcome by installing an automatic clock control which regulated the pumping schedule. This setup also permitted the operator to focus his attention on other matters. Unfortunately, however, this means of overcoming the withdrawal problem cannot be resorted to in the majority of plants, either by reason of the sludge piping arrangements or the pumping facilities available.

The proper piping arrangement, constructed with sound hydraulic practice, lends itself to efficient plant operation. Adequate connections should be provided for the transfer of sludge and the recirculation of supernatant. However, the practice of assigning too many connections and duties for one pump should be discouraged. The installation of sharp bends, especially 90 degree bends, should be eliminated from all lines if at all possible.

In the design of the sludge pipe line, consideration should be given to the viscosity and effect of temperature on the material to be pumped.

Dr. Hatfield, in his paper on "Viscosity or Pseudo-Plastic Properties of Sludges" which was published in the January, 1938 *Journal,* discusses the thixotropic property of sludge in relation to its viscosity. Merkel, from Dr. Hatfield's paper and after a study of the flow characteristics of Imhoff sludges, states that the material is thixotropic, that is, it loses much of its plastic resistance on stirring or mixing.

Dr. Hatfield, from the results of his own studies, found that sludges have an interesting property of losing a considerable portion of their apparent viscosity or plastic resistance on agitation. This thixotropic property of sludges suggests certain practical applications that might be considered in the pumping of thick sludges.

Viscosity is an inverse function of temperature; that is to say, as the sludge temperature falls the viscosity rises, becoming more resistant. The writer has knowledge of one plant in particular where the pumping time is twice as long in the winter as in the summer, due to the effect of temperature.

The installation of a sufficient number of valves and their proper location provides for more flexible plant operation and can also be a definite contribution to the safety of the operator. The safety viewpoint should not be minimized.

In one plant, special consideration was given to the safety angle in assigning the duties to the operators on the night shifts. The operator is required to call the foreman or the engineer before attempting any work outside of his regular schedule. This is especially true when work must be done in the chlorine room. This plant has had some unfortunate chlorine accidents in the past, which probably never would have happened had these precautions been taken sooner.

Though either the gate or plug type of valve may be more or less used generally throughout the plant, there are some conditions where one or the other is preferred. Some plug valves do not lend themselves to the necessary lubricating maintenance if buried in the ground. Out of sight—out of mind—too often applies to the selection and placing of valves. Though a plug valve may have the same cross-sectional area as a gate valve, the free horizontal clearance will be smaller and should be taken into consideration when being located in the system.

The disadvantage in the use of the gate valve lies in the number of turns required in operation, especially on the larger sizes.

In a number of plants, the transferring of sludge for the purpose of disposal or for further treatment is accomplished by the use of gravity. However, the use of this method as a motivating force has its limitations. The sludge pump has provided the means of overcoming those limitations and has been a forward step in making the plant more flexible in operation. The sludge pump may be called the focal point of the plant—so much is dependent upon it.

Sludge pumps may be of several types, the choice depending upon the size of the plant or the amount of sludge to be handled. In general, where large quantities of sludge are to be handled, the work may be done in a more suitable manner by the use of the non-clogging centrifugal type of pump.

The reciprocating type of pump is also used, however, it does have its greatest value in the smaller plants. The solids content of the sludge to be handled will have a bearing on the choice of the pump to be used. Where the percentage of solids content is not over 3 per cent, the centrifugal type of pump is more suitable, while the reciprocating type should be used for sludge with a solids content up to 8 per cent. Again, the pumping performance will depend upon the flowing characteristics of the sludge. Generally speaking, the centrifugal pump is suitable for secondary sludge, while the reciprocating type should be used for primary sludge.

Unfortunately, in most instances, the designing engineer is confronted with the problem of designing a plant as economically as possible, with the result that too often not enough pumps are installed. The initial cost of the extra sludge pump is of little consequence as compared to the better results that may be obtained by its addition. It provides for more flexibility of operation, and flexibility of operation provides for better plant results.

It is unfortunate that some designing engineers lack experience in plant operation. Such experience would most certainly result in providing more working space around the various units. Like other operators, the writer has had to do certain repair work standing half way up a wall or hanging by his knees. The writer was on the design side for more than thirteen years prior to becoming an operator and, therefore, does not hesitate to make this statement.

Many plants of the separate digestion type transfer sludge from the clarifier or clarifiers to the digestion tank only once a day because of labor conditions. Some perform this operation, despite labor limitations, twice each day, usually the first thing in the morning and again just before leaving for the day.

Time and again it has been demonstrated that a plurality of pumping operations or transfers are better than one. The sedimentation tank and the digestion tank both benefit from smaller and more frequent transfers of sludge increments. This is especially true where a raw sewage is stale and septic and particularly where there is a higher temperature range. To take an actual case which has recently been cited:

To begin with, the sewage solids were septic. In the interests of economy the clarifier mechanism was operated intermittently, usually for awhile each morning before pumping. The septic solids deposited on the tank floor in the preceding twenty-four hours had compacted and were further agglomerated by the gas bubbles formed during the rapid decomposition induced by the aggregation of the solids which were decomposing before arrival at the plant. Just as soon as the scrapers disturbed the mass, breaking into fragments the layer of solids, the entire mass bounced to the surface, buoyed up by the entrained gas.

Subsequent attempts to withdraw sludge from the hopper were productive of a brief "slug," then sewage water. Attempts to stir mechanically the hopper from above were unfruitful of results.

In addition to the labor angle, which is always a factor to be considered, the removal of floating material from the clarifier surface resulted in a deterioration of an otherwise excellent tank effluent, both in respect to the suspended and settleable solids and also the B.O.D. of the effluent. The remedy suggested was as follows:

1. Run the clarifier mechanism continuously.
2. Remove the settled sludge as frequently as possible from the hopper.
3. Start doing something about eliminating the cause or causes of septicity in the raw sewage if at all possible.

One plant, as has been previously stated, corrected this problem successfully by means of a dependable time clock auto-control on the sludge pump, whereby one minute of sludge withdrawal and transfer occurs every twenty minutes, or three minutes each hour. Normally this schedule meets the requirements, however, there are times when two-minute increments are required, and other times when the pump is taken off the auto circuit entirely. This is a matter of operation.

Proper sampling habits will also prevent the pumping of thin, watery sludge and contribute greatly to the efficiency of the digestion process and heating equipment.

While the foregoing discussion only covers certain units of the sewage treatment plant, they are of such importance that they can mean a great difference in plant results. A well-designed plant, properly equipped and with sufficient operating funds, in the hands of a competent and conscientious operator, will assure most municipalities of few serious difficulties.

SLUDGE DIGESTION—OPERATION AND CONTROL

By Albert B. Kozma

Superintendent, Rutherford (N. J.) Joint Meeting

Our discussion concerns itself principally with the operation and control of sludge digestion in separate sludge digestion tanks; operating procedures in Imhoff tanks and septic tanks will be only briefly mentioned.

The purpose of sludge digestion is to produce digested sludge by routine operation, without interruptions, in a manner reasonably free of offensive odors. In the end product the liquor should be readily separable from the solids.

Tank Capacity

At the present stage of the art, sludge digesters are fool-proof if properly designed, not outmoded or outgrown. The only exception is when industrial poisons are present in the sludge which inhibit the process. For this reason and under normal circumstances, the first step the operator should take in case of trouble, or preferably in anticipation of trouble, is to appoint himself as a committee of one and to investigate the design features of his tank.

The capacity of the tank is the most important item: 2 cu. ft. per capita in a plain sedimentation plant, 3 cu. ft. in a chemical treatment or trickling filter plant and 4 cu. ft. in an activated sludge plant are the minimum if the tanks are heated. For unheated tanks add at least 50 per cent. If industrial wastes are present or other unusual conditions exist, allow for the increased quantities of solids.

Many investigators prefer to rate digesters on sludge solids basis and call for 2 to 3 lbs. of dry solids per cu. ft. of tank capacity per month for complete digestion and 4 to 5 lbs. for primary digestion.

Next in importance in the design of sludge digestion tanks is the provision of adequate heating facilities, proper insulation, location above ground water level, if possible, etc. In the case of hot water heat one sq. ft. of coil area per 100 cu. ft. of tank volume is a good average figure. If special conditions prevail further investigations will have to be made such as outlined by Wittwer paper in *Water Works and Sewerage,* June, 1943, or by the writer in the January, 1943 issue of the same periodical.

The depth should not be less than 20 ft.; on the other hand, this dimension is limited by the surface area which should be sufficient to prevent the gases from causing undue agitation.

Types of Sludge Digestion Tanks

Various types are available such as those with fixed covers or floating covers. We distinguish single stage tanks from multiple stage tanks. Mixing and circulation of sludge can be accomplished by rotary thickeners, turbomixers or vertical propeller pumps.

Imhoff and Septic Tanks

Imhoff tanks are designed 15 to 35 ft. deep, with 1.5 to 3 hours of settling period and 1 to 3 cu. ft. per capita capacity in the sludge compartments. Septic tanks are designed for 8 to 24 hrs. detention.

Operation Objectives

The 60 to 80 per cent volatile content (dry solids basis) of the raw sludge is reduced to 40 to 60 per cent in the digested sludge, the percentage depending upon the treatment following the digestion process. If odor nuisance is a consideration higher removals are called for.

The average solids content of the raw sludge is 4 to 5 per cent, which will probably be increased to 8 to 10 per cent in the digested sludge.

The supernatant liquor should have a suspended solids content of not over 2,000 p.p.m., less than 100 ml. per l. of settleable solids and a 5-day B.O.D. not in excess of 1,000 p.p.m.

Backmeyer of Marion, Ohio used an ingenious scheme in his activated sludge plant to produce good supernatant; he mixed his digested sludge in the secondary digester with cold quarry water in a 1 to 2 proportion whereupon the sludge readily separated from the liquor.

Operation Controls

Under normal conditions the pH test, the tank temperature and the volume of gas produced is all the operator wants to know to find out whether his tank is operating satisfactorily. He is also interested in the percentage of volatile matter in the digested sludge before he discharges it.

Dr. Rudolfs found in his classical investigations that digestion passes through three stages, namely, (1) acidification (intensive acid production), (2) liquefaction (acid digestion), and (3) gasification (intensive digestion and stabilization). In normal operation the third stage predominates; hence the pH is at or near to 7. The temperature determines the rate of digestion; therefore, 4 to 5 per cent solids can be added to the digesting sludge at 80° F. and less at lower temperatures. Temperatures of 80 to 85° F. are considered optimum, both from the standpoint of the rate of the process and due to certain restrictions imposed by the hot water heating facilities (140° F. being the maximum safe temperature of the feed water). The volume of gas produced is usually 1.0 cu. ft. per capita or 10 to 15 cu. ft. per lb. of volatile matter digested.

When the tank is being started into operation or other unusual conditions prevail, further control tests will be necessary.

The carbon dioxide content of the sludge gas, if in excess of 35 to 40 per cent, predicts trouble one to two weeks ahead of time and it is an important test if acid conditions are anticipated. Its determination is very simple by means of an inexpensive gas analyzer, by bubbling the gas through potassium hydroxide solution.

If a more sensitive index is desired than the pH test, the total alkalinity test is suitable. It should not be less than 1,000 p.p.m.

In case of industrial wastes, it is advisable to control the process by means of the volatile acids which are determined as follows:

200 ml. of the sample is measured in a distilling flask; 5 ml. of concentrated sulfuric acid is added and 150 ml. distilled into a receiver. The distillate is titrated with 1/10 N sodium hydroxide and results are calculated as acetic acid (10 p.p.m. per ml. of sodium hydroxide) and reported in p.p.m.

A recently proposed test by the engineers of the Dorr Company calls for the determination of the ratio of free carbon dioxide to the alkalinity. To avoid the direct determination of the free carbon dioxide, which is a rather cumbersome process, they propose to follow the procedure outlined by Prof. Hoover in his book entitled *Water Treatment*, page 161, consisting of the determination of the pH and alkalinity directly and in the computation of the free carbon dioxide from the following equation:

$$pH - 6.3075 + \log CO_2 = \log \text{alkalinity}$$

where both the CO_2 and alkalinity are expressed in p.p.m., the latter in terms of $CaCO_3$. A graphical chart is available to determine the free carbon dioxide from the other two values. This method appears to be much simpler than the volatile acids determination and has interesting possibilities.

Control of Acid Conditions, Scum and Temperature

The control of acid conditions, scum and temperature is somewhat interrelated. The most common method used to rectify acid conditions is by addition of lime, although ammonium sulfate treatment was used in places. The latter has found considerable application in the control of disturbances caused by industrial wastes, also in the control of scum.

For controlling scum, high temperatures are recommended, attainable by insulating the top of the tanks or, as Mr. Taylor, Consulting Engineer of New York City, advocates, by using jetting pipes to sprinkle supernatant on the top of the scum. The latter method breaks up the scum besides heating it. Hood of Ridgewood, N. J., has been successful in controlling scum with activated carbon.

For maintaining uniform temperatures and increasing gas production, the recirculation or mixing of the sludge is found to be useful.

Sludge Input and Withdrawal Technique

If means are available to dispose of the sludge at regular intervals all year round, such as by covered sludge drying beds or vacuum filters, the amount of ash in the digested sludge withdrawn should be the same as in the raw sludge added. If, however, sludge drying facilities are limited at the beginning of the poor drying season, the digester has to be sufficiently emptied to make room for the raw sludge received during the poor drying period. We have not time to fully outline the arithmetic of this problem but merely point out that sufficient seeding sludge should be left in the tank so that if an average tank temperature of 60° F. is anticipated, the daily amount of fresh solids added should not exceed 2 per cent by weight, and at 80° F. the daily charge should not exceed 4.5 per cent.

Gas Production

The digester gas is a valuable by-product of the digestion process and careful attention should be given to its full utilization. Its average methane content is 70 per cent and its heat content 600 B.T.U. In 1–5 to 1–12 mixtures with air the gas is highly explosive and for this reason and that it is an asphyxiating gas, we cannot place enough emphasis on the need that safety precautions be strictly followed. The maintenance of safety devices such as flame traps, vacuum relief valves, grounding of motors, explosion-proof lighting fixtures, etc., is a *must* in any plant. Prohibition of smoking, elimination of water seals, closing of petcocks after manometer readings, closing of automatic condensate drip traps, and checking of automatic gas pilot valves are equally important precautions.

The principal use of this gas is to heat the tank, and to accomplish successfully this purpose it is very important to keep the boiler clean, not to operate it under 180° F. and to use hot water mixing valves to cut this down to 140° F., the maximum permissible temperature in the coils. Care should be taken to maintain proper gas pressure (usually 2 inches) at the gas burners.

If gas is used for power generation further steps must be taken to suit it for the purpose. The maintenance of the machinery presents some problems but the scope of this paper does not permit us to go further into this subject.

Starting the Digester

The starting of the digester is a most difficult manipulation if no seeded sludge is available. There are two schools of thought as to the procedure. The first recommends filling of the tank with sewage to avoid dangerous gas-air mixtures, then slow introduction of heavy sludge with heat from an independent source of fuel supply. Temperature and pH control, addition of lime and recirculation will eventually help to attain the desired end. On the other hand, the Dorr Company does not recommend the use of sewage but sludge alone. Sludge should be pumped as thick as possible and it should be heated as soon as it reaches the heating coils; then proceed as outlined above. The roof hatches will not be closed until actual gas production starts, to be sure that all air is expelled.

Cost of Operation

At the Joint Meeting at Rutherford, the 1942 fixed charges amounted to $2.35 and the operating charges to $3.00 per dry ton. Average figures are $3 to $4 for fixed charges and $2 to $3 for operating charges.

Garbage Digestion

At Cornell University, experiments were conducted by Malcolm and Straub on the digestion of garbage and pure vegetables mixed with sewage sludge. They found that the pH and volatile solids were slightly higher than in digested sludge alone. About 13 cu. ft. of gas was produced per lb. of volatile matter, which gas contained 40 per cent carbon dioxide, therefore, having a lower B.T.U. value than in the case of ordinary sludge digestion.

The digestion of garbage offers interesting possibilities for disposing of this troublesome material and for power production, after some of the inherent difficulties are ironed out. The little information available indicates that combined sludge and garbage requires twice as much digestion tank space per capita as sludge alone.

SLUDGE DEWATERING

By J. K. Adams

Superintendent, Sewage Treatment Plant, Tenafly, N. J.

This title could include a dozen or more subdivisions, each of which would supply material for an entire paper, so I can only touch the high spots. Sludge dewatering is still the principal problem at most plants and it is accomplished in various ways.

It is worth noting that, although widely practiced, dewatering is not always necessary. Wet sludge may be disposed of by dilution in large bodies of water as is done by several cities located near the ocean. It may also be disposed of on land by discharge to low ground or into trenches or lagoons. Where this is done in the United States it is usually with apologies and an explanation that it is an emergency measure due to lack of sludge bed drying area or for temporary use during winter months. The objections to it are obvious, even for digested sludge, while raw primary or raw activated sludge, so handled, creates a serious nuisance due to odors and flies.

Returning to the dewatering problem, the principal reason for taking this step is to reduce the volume of material to be handled, whether it be for ultimate disposal on land as fill or for fertilizer or by incineration.

Even in this mechanical age sand beds are the most widely used means of dewatering sludge.

Mr. Langdon Pearse's report to the A. S. C. E. in January 1944 (4) states that in 1941 there were 3,909 places using sludge drying beds of which 348 were covered. By far the larger part of these installations are for drying digested sludge, for which they are particularly suitable. Raw sludge is difficult to dewater on beds and is very odorous. There is seldom any trouble with odors from a well digested sludge, but if necessary to place raw or partially digested sludge on drying beds, steps should be taken to minimize the odors. Hydrated lime or chloride of lime are helpful. These have been added to the wet sludge or sprinkled on the surface of the sludge layer. Donaldson reports that 1 to 2 pounds of copper sulfate per 1,000 gallons of wet sludge was effective in reducing odors from raw activated sludge on covered beds at Tenafly. However, this practice was only continued a short time, and is not necessary when sludge is removed within 48 hours.

The use of a coagulant as an aid to drying digested sludge on beds has not been widely resorted to but in 1940 Sperry at Aurora, Illinois (1) described the effectiveness of alum for this purpose, confirming results as early as 1923 by John Downes at Plainfield (2). Sperry reduced drying time from 20–25 days to 12–15 days by using 1 pound of alum to 12.5 cubic feet or 93 gallons of sludge. This is 1.8 per cent conditioning, dry basis, on a 7 per cent sludge. It was effective with sludges of solids content up to 8 or 9 per cent, but less so for heavier sludges. On sludges under 3 per cent he found that a dosage as low as 1 pound to 200–300 gallons was as effective as a heavier application. The Aurora sludge is a well digested product averaging 47.4 per cent volatile and 6.9 per cent total solids. The benefits found here differed from Downes' earlier tests in that Downes found a decided advantage in adding alum to poorly digested sludge but very little improvement was noticed when added to a well digested sludge.

Sperry attributes the effectiveness of alum to its sulfuric acid content rather than to its aluminum oxide. The acid releases CO_2 which helps to float the solids and makes the sludge porous. This is borne out by the results obtained by Johnson at Great Neck, N. Y., who used 95 per cent sulfuric acid with similar results. There seems to be a slight advantage in cost per ton of sludge by using the acid but other considerations, especially safety factors, will usually outweigh the savings made. Ferric chloride and sulfate were found to give results comparable to alum but cost more and have a tendency to plug the sand beds, according to Sperry.

He also emphasized the need for coarse sand and ample under-drainage and pointed out that alum-treated sludges are less affected by rain than sludges not so treated and hence alum is especially valuable during winter and other wet seasons. He states that the cost of the alum was saved at Aurora due to speeding up dewatering in winter. It would certainly seem worthwhile for any operator confronted with a similar problem to investigate its effect at his own plant.

At Hackensack, Lehman got no benefit from alum when applied to digested sludge in the same manner as at Aurora—at the point of entrance to the bed. He thought the sludge might be too thin (about 3 per cent solids) to notice the difference in drying time—about 2 weeks in clear weather or 4 to 6 weeks in poor drying weather.

At Tenafly we have no opportunity to compare results as we have no digesters and only handle one type of sludge—raw activated. Prior to May, 1936, we were using alum to dewater this sludge on covered drying beds. The results varied greatly from week to week and even from day to day. Sometimes the sludge could be removed on a fork the next day, but very often it remained in a semiliquid or liquid condition and had to be removed slowly by shoveling or by pumping into the adjoining marshland. The alum was added by a rule of thumb based on centrifuge test and number of gallons. It averaged 12 to 15 per cent solids, dry basis. Twenty-five hundred to five thousand gallons were run on to the bed at one time depending on the solids content and how well the sludge was drying.

Other coagulants were tried, particularly ferric sulfate and ferric chloride, and we soon found that our sludge bed dewatering troubles were about over. We found that by using 4 to 5 per cent ferric chloride (dry basis) we could remove the sludge from the greenhouses on a fork the next morning after draining 10 to 20 hours. The sludge cake was 3/4 inch to 1 inch thick, and firm and easily handled. Moisture would run 87 to 89 per cent. The original depth of fill was about 8 to 9 inches with sludge running about 0.5 to 0.75 per cent solids and 74–76 per cent volatile.

At the present time we get as good or better results on heavier sludge (1 to 1.5 per cent solids), the resulting cake being about 1-1/2 inches thick from a 6,000-gallon draw. This is resorted to by us only as an emergency measure when we cannot remove our daily quota of sludge on the vacuum filters and flash dryer.

Probably the rather unusual nature of our sludge will make these details of only slight interest to operators producing digested sludge. I should say that after using either coagulant for several months we found that a black layer 2 or 3 inches thick developed just below the surface. This accompanied an impairment in drainage and was cured by turning over the surface of the bed with a fork and exposing it to the air for 2 or 3 days. The black color disappeared and after raking, the bed was good for another few months. Sand is added each day to replace that removed with the sludge. We try to get coarse sand but there is considerable clay even in the best washed bank sand we can get locally.

This runs about 0.25 mm. effective size and the uniformity coefficient is below 4 but it will have 2 to 3 per cent fine enough to pass a 100-mesh sieve. We have very little choice, having to take whatever is available nearby. As is often the case at sewage plants, our sand beds are too low and in very wet weather the ground water interferes with drainage.

Regardless of whether or not a coagulant is used for digested sludge, Parkes of Pasadena, Cal. (3), suggests that shortage of sludge drying area can be partly offset by drawing thinner doses more frequently, as the thin cake will crack quicker and help removal of water by evaporation. He finds that drainage stops in about 48 hours and after that the remaining water is lost by evaporation. A good brief discussion of desirable sludge depths was given in the "Question Box" of the August, 1943, *Sewage Works Engineering.*

Coming now to mechanical means of dewatering sludge, a great deal of valuable information has been published in the last three years. A need to speed the process and save space has turned many designers to newer methods, though it must still be admitted that for small plants the older sand bed dewatering system will prove more economical. However, local conditions may call for complete disposal of the sludge by incineration or for use as fertilizer.

Of the several mechanical methods available, only one has become important in sewage works—the rotary vacuum filter. Several trial centrifuge installations have been made with varying degrees of success. A reduction in moisture from 90–95 per cent to 50–70 per cent was claimed on trial runs without use of chemicals, vacuum pumps, complicated drainage systems or filter covers, and all in a small area. The chief problem was unloading and the large size required for satisfactory dewatering. I do not know of any in actual plant installation on sludge, and the principal manufacturer of sewage works installations is now out of business. Sludge presses have been used and discontinued as unsatisfactory.

At Plainfield, N. J., a method is used which carries dewatering through to incineration by means of spray drying and then burning of the dried particles by mixing with a powdered combustible waste product of coal tar origin, in a specially designed furnace and drying tower.

Beaudoin of the Sanitary District of Chicago (5) reports a new method of reducing the water in activated sludge filter cake by means of electric voltage. He states that it is not economically feasible at this time.

Dewatering on vacuum filters may be followed by drying by means of heat for the production of fertilizer or complete destruction by burning. A very thorough discussion of this practice was presented in a series of papers before the A. S. C. E. (7) last year. I shall only attempt here to touch on a few filter operating practices as reported in various publications, with a few side-lights from our experiences at Tenafly.

I would like to mention first elutriation, which promises such remarkable possibilities for improved operation of filters and savings in operating costs. The principal elutriation installations are at Baltimore, the District of Columbia, Annapolis, Hartford, and Springfield, Mass. At the end of 1943 there were 12 plants in this country using the process.

It has been used successfully at Hartford by G. H. Creamer for about 5 years (6). Describing the "counter current" elutriation process as used by him, Mr. Creamer says, "Two mixing tanks and two sedimentation tanks are used. Digested sludge is mixed in the first mixing tank with water from the top of the *second* sedimentation tank. The mixture then passes into the first sedimentation tank from which the supernatant water overflows, returning through the entire plant. The solid matter settling in the first sedimentation tank is transferred to the *second* mixing tank and there mixed with approximately 3 times its volume of clean water pumped from a group of 36 well points driven into the coarse sand underlying the plant. This mixture is settled in the second sedimentation tank and the supernatant water overflows to the first mixing tank as stated above. The sludge passes to the conditioning troughs and then to the filters.''

Ferric chloride required to condition the sludge was only 2.51 per cent, producing a cake of 61.9 per cent moisture. The tests conducted at Baltimore in 1933–34 showed that at any rate of filtration the coagulant can be reduced to about 0.4 that required without elutriation. At Hartford in 1941 it was also found that digestion time could be cut from a 60-day period to 30 days, resulting in a net saving of $3,800 in the construction cost by using smaller digestion tanks and adding elutriation tanks and equipment. Even 15-day digested sludge could be readily filtered but required up to 3.5 per cent ferric chloride. Best results were obtained when the filtrate pH was 6.0 to 6.3. No lime was used. Creamer also credits elutriation with prolonging the life of woolen filter cloths to about 800 hours.

Fuhrman of the District of Columbia (7) sewage treatment plant also reports important savings in coagulant by using elutriation. Incidentally, this process is patented by Mr. A. L. Genter of Baltimore and the cost of royalties must be included in total costs.

Fuhrman mentions several causes of deterioration of woolen filter cloths and gives some remedies. He finds it important to wash filters for 30 to 45 minutes after each run. He also recommends soaking the revolving filter drum for 24 hours in a 1 per cent oxalic acid solution, thereby increasing hours of service from 528 to 682, or 30 per cent in one instance. He applied a 100 p.p.m. solution of copper sulfate to prevent growth of mold or bacteria that destroyed the cloth. The filter was rotated as above long enough to saturate the cloth whenever it was to be shut down more than 16 hours. Whether these cloth difficulties would have been encountered regardless of elutriation is not stated but presumably they would be at least as bad with unelutriated sludge. In fact, Weber at Annapolis reports (8) lengthening filter cloth life from 150 to 1,000 hours by elutriation, and this without any need for acid washing of cloths.

At Tenafly we soak our wool filter cloths overnight in a solution of Oakite 31W when they show blinding. We can often get several weeks more use by doing this. Then, after the cloth does not respond to this treatment we remove it and soak it in the same cleaning mixture and after a few days of this, follow with a good rinsing and the cloths are in excellent filtering condition again. This treatment was not successful on cotton cloths, which we tried unsuccessfully to use several years ago.

Fuhrman also found that a detention period of 15 to 20 minutes for elutriation as originally used was not necessary and he reduced this to about 20 seconds with the additional advantage that he stopped settling out of fine sand in the mixing tanks.

Regarding cloth washing, it may be of interest to note two contributions that should be of use to operators. These are both from Minneapolis-St. Paul, one described by E. L. Mick (11), Chief Chemist, as an inhibitor to the action of muriatic acid on the metallic parts of a filter. A 2 per cent aniline oil dosage (figured on the weight of pure HCl) is effective in reducing the rate of corrosion from 44 per cent in a weak (0.7 per cent HCl) solution to 97 per cent in a 5 per cent solution. More aniline is needed for stronger acid and produces less effect. The aniline oil is mixed with the acid in the carboy and enough water is run into the filter pan to just submerge a portion of the drum. Then the acid is added to the water with the drum turning and the agitator in action. After about three hours, the cleaning solution is drained and the filter washed. At Minneapolis-St. Paul they do this after 350 hours of service and by removing the scale this way the cloth life is prolonged to 500 or 600 hours. This removes the carbonate from the wire backing and wooden parts as well. To do the same for the piping, the acid is recirculated through the filtrate pump.

The other suggestion from the same plant is given by G. J. Schroepfer, Superintendent (7). He finds that improved washing will result from making the water jets impinge almost at right angles to the drum, instead of at a tangent as usually.

However, the use of inhibited acid is not always satisfactory. Lynch and Mann at Auburn and Cortland, N. Y. (12), say the effects of using a mild solution were negligible and, if a strong enough solution was used to do a good cleaning job, the cloth went to pieces soon after. They concluded that the age of the cloth had more to do with its useful life than the actual hours of service.

This fact was confirmed by Dundas at Chicago (7), filtering raw activated sludge, while at Auburn they filtered raw primary using ferric chloride followed by lime and at Cortland they handled digested sludge by adding the lime first, then the ferric chloride.

I should mention here some of the progress reported recently in sludge dewatering but along more conventional lines than elutriation.

Commenting on the A. S. C. E. symposium on sludge dewatering in January and February, 1943 (7), Dr. Rudolfs summarized the essential requirements for efficient vacuum filtration as follows:

1. Sludge should be concentrated as much as possible.
2. Filter operation should be as nearly continuous as possible.
3. A conditioning agent must be used.
4. The conditioning agent must be added in accurate proportions and thoroughly mixed in the shortest possible time.
5. Filtering should proceed as soon as possible after mixing to take advantage of the floc formed.
6. Flexible machinery and close control are essential.

I tried to make comparisons of dewatering costs at different plants but the variables in each plant as regards volume of material handled, type of sludge, process details, and so forth make it almost useless to compare costs unless a great amount of detail can be set forth with the cost figures. A very low figure of $3.50 per ton of raw dry solids at Minneapolis-St. Paul (7) covered vacuum filtering and incineration while a figure of $9.38 per ton of dry digested solids at Buffalo (7) covered vacuum filtering and flash drying.

Two large plants at Cleveland, at which digested sludge is vacuum filtered and incinerated, place dewatering and incineration costs at $10 per ton at one plant and $14 at the other in 1939. Small plants will have a much higher rate per ton, reaching $20 per ton or higher, according to Rudolfs (7).

Lehman at Hackensack, N. J., states that the dewatering cost is about $16.40 per ton of digested dry solids, $8.20 per ton on a raw solids basis, $10 per m.g. sewage flow or $2.70 per 1,000 gal. sludge filtered. This is for primary and raw activated sludge mixed and digested, then vacuum filtered and dumped on low land.

At Muskegon, Mich., dewatering costs in 1940 on vacuum filters handling digested sludge were reported by C. T. Mudgett (10) to be $8.00 per ton of solids filtered, including carting away cake. This plant handles 4–5 m.g.d. raw sewage.

At Tenafly, the dewatering system is unique for very small plants although it is used by a dozen other plants, some very large, including Chicago and Buffalo. It consists of vacuum filtration of raw activated sludge conditioned by ferric chloride and followed by "flash drying" the filter cake to about 10 per cent moisture for sale as fertilizer. We get most of our heat for the final drying from a garbage and rubbish incinerator. Oil is burned when other heat is not available. We spent about $5,300 in 1943 for vacuum filtering and drying or $46.50 per ton, dry basis. A breakdown of this figure, which is based partly on estimates, is given below. Costs are based on 1943 production of 113 tons dry basis, which is 73 per cent of the total solids wasted.

Item	Cost per Ton Dry Solids
Power	$ 2.90
Water	1.80
Labor	25.80
Ferric chloride (6½ per cent)	7.30
Filter covers, wire, etc.	1.40
Fuel oil	6.20
Bags (for only ⅓ production)	1.10
Total	$46.50
Equivalent to	$41.85 basis 90 per cent moisture
Revenue from fertilizer sold	$23.30 basis 90 per cent as sold
Net cost of dewatering	$18.55 basis 90 per cent as sold
Net cost of dewatering	$20.60 per ton dry basis

The figures do not include major repairs, overhead, or supervision. Comparative costs for removal via our sand beds are:

Item	Cost per Dry Solids
Labor	$13.75
Ferric chloride (5 per cent)	5.60
Sand	2.15
Total	$21.50

It appears that with a favorable fertilizer market such as we now have, we come out a little on the right side of the ledger as compared with the old method. If we had some spare equipment, enough to prevent several long shut downs for repairs, we could increase the revenue materially, assuming that we can continue to get $20 to $30 per ton for our fertilizer. Cost per ton drops as production increases.

While on the subject of equipment maintenance I would like to suggest study by filter manufacturers of means to speed up and facilitate the changing of filter covers. With us it means we lose an entire day's operation when changing covers on one of our two filters. I wonder if individual removable filter sections could be provided so that a spare set could be covered with cloth ahead of time, ready to put in place of the one removed. Clamps or screws at each end combined with some interlocking device along the length of each section would eliminate the need for metal crimping rods or winding wire. Perhaps the cloth on one section could be left overhanging slightly and pressed into the longitudinal groove by the edge of the adjoining section, thus completing the seal.

Some steps in this direction have already been taken at Chicago (4). An arrangement is used whereby the backing is divided into panels and a groove left between each panel into which the cloth is crimped by a wooden spline nailed down. This permits use of narrower cloths which cost less. They are also experimenting with wooden backing instead of wire mesh, which has not proved satisfactory there. This new arrangement eliminates winding wire also.

With regard to the brass drainage piping inside the filter drums and elsewhere, we had to replace all of this after 3 years' service and some of the fittings more often. We plan to use Saran plastic pipe and fittings the next time it is necessary as these will not be affected by the low pH of our filtrate. Chicago has been trying this type of piping with very satisfactory results.

Buffalo reports the use of sash cord in place of bronze strips to hold cloths. They find it easy and quicker to apply and less expensive.

At Tenafly we are using copper mesh wire $4 \times 4 \times .063$ ga. for backing. This has to be renewed every 18 to 21 months. Our winding wire is No. 12 bronze and we use it over again many times. We use bronze welding rods for crimping along each section. One more point about filtering—Schroepher at Minneapolis-St. Paul reports (7) important reductions in operation and maintenance costs by reducing the filter rate. He finds that these costs at a 2 lb. per sq. ft. per hour rate are less than half what they would be for a 7 lb. rate. Considering operation and maintenance costs only, the economical rate is about 1 lb. but figuring on the basis of total annual charges, the economical rate is about 2 lbs. per sq. ft. per hour. These figures are rather startling in view of the generally held opinion that a thick filter cake and high yield per hour are indicative of higher efficiency and lower costs. It is a delicate problem in balancing various cost items for large plants but I feel sure that for small plants, where labor is such a large part of our total costs, we should continue to try to get as high filter rates as possible.

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DISPOSAL OF SLUDGE AND SUPERNATANT

By George H. Eckert

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The sludge that is drawn from a sludge digestion tank or from the sludge compartment of an Imhoff tank has merely been prepared for disposal. The operator must provide an inexpensive method of disposing of it, and at the same time must dispose of it in a manner that will not create an offensive odor nuisance. Undigested sludge must generally be dealt with in a different manner than a well digested sludge, principally because of its more offensive odor.

The trench and cover fill method is one common means of disposing of undigested sludge. It is hardly necessary to describe this procedure in detail. Another method, particularly in large plants, is incineration, to which some reference has been made in the preceding paper. Lagooning of sludge drawn directly from the digester is also commonly practiced and is justified in many cases because disposal can be effected satisfactorily and economically in this fashion. It is usually advisable only where the plant is isolated and where natural lagooning areas are available. Shallow lagoons may be used in a manner similar to sludge drying beds, the dry sludge being removed for disposition as fertilizer or land fill.

Grinding is possible when sludge is sufficiently dry. By drying, grinding and bagging it may be sold, as is the method of disposal at some plants. No method of municipal sewage sludge disposal can normally be made financially remunerative in the sense that receipts from the sale or use of this product of the sewage treatment works will exceed fixed charges as well as expenditures for maintenance and operation. Sludge has some fertilizer value and in some cases farmers will haul it away, but they will rarely pay for the sludge itself.

A very interesting article in the June, 1942 issue of *Water Works and Sewerage,* "Values of Sewage Sludge," by Dr. Willem Rudolfs, is the basis of some of the following information. The use of various types of sewage sludge as sub-grade fertilizer or soil builder has been advocated for many years. There has been some enthusiasm on the part of users of the material, but many soil technologists and soil scientists continue to wonder why sludge is not more generally returned to the soil for its plant food and fertility value. Sewage plant operators have tried to stimulate its use with not too much success.

An inquiry to determine why the material is not used on a larger scale, especially from smaller plants, or why the use has been discontinued, seems to indicate several reasons which can be summarized as follows: (1) insufficient knowledge of the value, (2) improper use of the material or insufficient preparation, (3) excessive claims made for it and (4) lack of interest in it.

From the hygienic standpoint there is no problem if the sludge is used in the proper manner. An extensive inquiry made to determine whether ill effects have been observed on animals or human beings shows that where land disposal has been practiced for many years no disease or epidemics have occurred.

The determination of the values of sewage sludges has chiefly been a matter of testing for the principal fertilizer ingredients (nitrogen, phosphorus and potash), while sometimes the organic matter content is taken into consideration.

An analysis of digested sludge samples submitted from the Ridgewood, N. J., sewage plant in 1938 and analyzed by Charles Cathcart, State Chemist of the Co-operative Extension Department, New Brunswick, N. J., shows the following: water—35.2 per cent; organic matter—31.15 per cent; total nitrogen—2.07 per cent; total phosphoric acid—3.57 per cent; potash—0.64 per cent. For comparison, it should be kept in mind that the average fertilizer ingredients of barnyard manures are about 2 per cent nitrogen, 1 per cent phosphorus and 1.5 per cent potash. It is evident that, in addition to the main fertilizer ingredients, small quantities of minor elements are present in the sludge and those may play an important role in plant growth. As a soil builder, the humus content of sludge is less than that of barnyard manure but is still of considerable value in sandy and heavy clay soils. With the advent of the war and the sudden interest in Victory gardens, sludge as a soil conditioner and fertilizer has gained some recognition. It is the operator's duty to point out the values and uses of sludge whenever opportunity presents itself, because this is another means of disposal. It is not advisable, however, to advocate its use for the fertilization of crops which are served in an uncooked condition.

Sludge may also be used as fill in a dried or wet form and in many cases has been used to fill low lands that surround sewage treatment plants. The use of sludge fill in the very low places followed by planting and landscaping helps to beautify the plant site.

The disposal of sludge is not the only problem with which the plant operator must contend. The overflow from the digestion tank, or supernatant, frequently offers a problem in disposal, since both the solids content and B.O.D. are very high. It is rather common practice to discharge this back to the inlet of the sedimentation tank. In some plants this method of disposal is satisfactory; in others it appears to affect adversely the quality of the effluent. The strength of the supernatant, the capacity of the digester and the characteristics of the sewage are factors. In plants using chemical precipitation, the supernatant returned to the sedimentation tanks often interferes with coagulation and usually increases the amount of chemical required to form a satisfactory floc. In plants employing either plain settling or chemical precipitation, interference by the supernatant can be reduced by returning it in very small quantities over the 24-hour day. Some attempts have been made to treat it on sand beds, as on sludge drying beds. To my knowledge, there is no established satisfactory method of supernatant disposal, but at several plants great strides have been made and a considerable amount of study has been given this problem. At the Hasbrouck Heights plant, we have had the usual difficulties with separating the sludge and water in our digestion tank, and our supernatant liquor has been so charged with solids that its disposal has been extremely difficult. When the solids in the supernatant run high, the supernatant liquor is disposed of on sludge drying beds. When the solids content of the supernatant liquor is low, it is returned to the influent sewage and there chlorinated.

The practice of returning supernatant for complete treatment through the plant processes is to be desired and preferred over lagooning methods. By the former, however, troubles may ensue at other plant units. By the latter method, unsightly conditions and odor nuisance may result unless the supernatant has been chlorinated before discharge to the lagoon.

Mr. A. E. Griffin of the Wallace and Tiernan technical service is, perhaps, qualified to give a picture of the chemical reactions which occur when chlorine is applied, as I believe he has checked experiences in supernatant chlorination in the plants at Morristown, Little Falls, Ridgewood, and elsewhere. As far as we are concerned, the advantage of the treatment lies in the modification occurring in the carbonate equilibrium which, combined with the reduction in B.O.D., substantially reduces the shock load on the plant and permits return of the supernatant to the sewage without causing a reduction in overall plant efficiency.

In experiments at Ridgewood in August, 1943, 6,000 g.p.d. of supernatant was chlorinated to a residual of 20 p.p.m. The treatment reduced the alkalinity from 3,230 p.p.m. to 1,210 p.p.m. and lowered the pH from 7.1 to 6.0.

This step combined with a proper technique in spreading the return over the period of highest plant inflow minimizes the load on the plant and makes it possible for the plant to function satisfactorily when otherwise it might not. At the Ridgewood plant, the supernatant return is distributed over the entire 24 hours, thus attaining a maximum of dilution. This precaution alone has sufficed to prevent upset of the other biological plant processes.

A DISCUSSION OF THE SYMPOSIUM ON SLUDGE *

By H. Heukelekian

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These papers deal with four important operational phases of the sludge problem; namely, (1) collection and pumping, (2) digestion, (3) dewatering and drying, (4) the disposal of supernatant liquor. Because of the time limitation, a comprehensive discussion of all the different phases cannot be attempted. Certain specific problems, however, will be discussed. In order to limit the scope, the discussion will deal mainly with primary sludge.

The frequent removal of sludge from sedimentation tanks is essential and is now generally recognized as good practice. The disadvantages arising from infrequent removal of sludge are: (*a*) deterioration of the effluent, (*b*) scum formation in sedimentation tanks, and (*c*) possible retardation of digestion. In addition to frequent removals of sludge, thoroughness of removal should also be emphasized. If sludge is not completely removed from corners and side walls of the tanks, it seeds the freshly-accumulated sludge and speeds up septic action, especially during the summer months.

The frequent removal of sludge, on the other hand, is usually accompanied by a sludge of low solids concentration, entailing the addition of large volumes to the digester and resulting in cooling the tank contents and reduction in the capacity of the tank. Slow rate of removal of the sludge from the clarifier sump prevents cone formation

* Journal Series Paper of the New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, New Jersey.

and the transfer of thin sludge. If maximum concentration of sludge is desired, thickening in separate or especially designed hopper tanks before addition to the digester is called for. The advantages of such a scheme would be a greater separation of liquor than is feasible in the digester, where evolution of gas prevents quiescent compacting, except in two-stage digesters especially designed for this purpose. Fischer has shown that concentration of fresh solids retards digestion but that retardation is very slight and is more pronounced with concentrations above 12 per cent.

Studies show that compacting of fresh solids is affected by time, temperature, and initial concentration of solids. The rate of compacting decreases with increasing concentration. The rate of concentration is greatest during the first 12 to 24 hours and decreases gradually thereafter. It is possible and may prove desirable to obtain solids concentration of 10–15 per cent with storage under quiescent conditions. Temperature has an important bearing on the rate of compacting of sludge, greater concentration being obtained during the summer than in winter with equal periods of quiescent compacting. Pumping difficulties, due to greater loss of head, will increase with greater solids concentration and with lower temperatures.

The septicity produced during the compacting period will have little if any effect on the rate of digestion, but too high a concentration of solids in the digesting mixture may retard the digestion, because of high concentration of intermediate and end products such as volatile acids accumulating in the smaller volume of liquor.

From the standpoint of digester operation, the uniform loading of the raw solids, whether compacted or not, makes for more successful results than does intermittent application of large batches. A more uniform gas evolution can be expected from such a procedure.

At present, the digestion of raw sludge of domestic origin in tanks of adequate capacity and with heating facilities offers few major problems. The gross changes taking place during digestion in respect to the quantity and quality of gas, volatile matter reduction, and the importance of optimum pH value are well recognized and need little emphasis. What is urgently needed for further progress in this direction is a more thorough and intimate understanding of the intermediate reactions which result in these gross changes. It is quite possible that the same end results may be obtained under slightly different conditions through different channels and side reactions. As the complete chain of events during the complicated process of digestion is better understood, it may be possible to direct the course in certain directions in order to obtain certain desirable products or to accomplish the stabilization of sludge in shorter time. In order to decrease the digestion time from 35–40 days we must find out what the slowest reaction is, in the whole chain of events. We recognize now that digestion entails two main and entirely different processes; the first liquefaction or hydrolysis, which is the preliminary stage in rendering the complex and large size materials into forms more readily available for the methane fermenting organisms which take part in the second stage and convert the liquefied and hydrolyzed materials into methane and carbon dioxide. This is the gross picture. There are, however, wheels within wheels in each stage and the above generalization does not adequately convey a picture of the complex and manifold reactions within each stage. It might be surmised that liquefaction is the slower of the two stages since, if material in a soluble form such as sugars is used instead of complex and large organic particles as in raw sludge, the speed of digestion and gasification is greatly accelerated and greater loadings per unit tank capacity can be made. Attempts to accelerate liquefaction by the addition of external sources of enzymes have not been fruitful. Preliminary septic digestion of fresh solids before their subjection to methane fermentation with ripe sludge has not resulted in curtailing the digestion time. On the other hand, we also know that the accumulation of too great a concentration of liquefied products such as volatile acids is not healthy for methane fermentation. In other words, if the rate of liquefaction exceeds greatly the rate of gasification, because of either a depression of the activities of gasifying organisms or an acceleration of the activities of liquefying organisms, the whole process of digestion is upset. It appears from the foregoing that both stages must be accelerated to the same extent if further increase in the efficiency of digestion is to be expected.

It appears that the addition of inorganic nitrogenous compounds such as ammonium sulfate as suggested recently by Schlenz is not the answer to this question. It has been shown that the ammonia nitrogen content increases from 100 p.p.m. in raw sludge to 1,000 p.p.m. in digested sludge, thus indicating that nitrogen for the growth of microorganisms is present in the sludge in quantities greater than required.

Sludge digestion, in addition to stabilizing and reducing the volume of the sludge, is a preparation to increase the rate of dewatering of the sludge. Emphasis will be placed here on the dewatering of the sludge on sand drying beds, since this method is more simple and economical for small installations, although some of the generalizations apply to vacuum filtration as well. There are two forces which operate in dewatering of the sludge in sand drying beds: first, drainage, and second, evaporation. Drainage is more pronounced during the first 12–18 hours. The flow by drainage is uniform during this initial period and is negligible thereafter. If the sludge is well digested, release from the tank pressure will liberate sufficient gas to float the solids and permit the drainage of the liquor through the bed rapidly. To assist this, natural process acidification of the sludge or alum application will liberate more gas from carbonates and induce flotation of the solids. Experiments have shown that drainability of the sludge increases with increased gas production and that optimum drainability of sludge coincides with the period shortly after the peak of gas formation. Storage of digested sludge decreased the drainability.

Of the two forces, drainage removes a greater percentage of moisture (60 per cent), at prevailing bed temperatures up to 130° F., than evaporation, which is the slower of the two forces. Naturally, drainage is not affected so much by an increase in temperature as is evaporation. Since circulation of air increases the rate of evaporation, the surrounding walls in an open drying bed should not be built too high. South African experiments have shown that the effect of rain is not so considerable as is generally supposed. Its effect varies according to the length of time the sludge has been on the bed before the rain. When rain falls before drainage has stopped, all the rain passes right through the sludge and the bed, just as though there had been no sludge. There is no tendency to absorb the rain. When rain falls after drainage is complete and while evaporation is a major factor, the rain does not drain through the bed but is absorbed by the sludge. The cracks are reduced in size and the drying time is increased. When rain falls after the sludge is thoroughly dried out and the cracks are large, extending down to the surface sand, it is not absorbed to any large extent by the sludge but flows rapidly through the bed.

In discussing the supernatant liquor problem it might be well to define what constitutes an ideal or good supernatant liquor. Under ideal situations the supernatant liquor should have only a small quantity of settleable solids, should be low in suspended solids and B.O.D., and should have a brownish color. There are no accepted standards for the quality of supernatant liquor, but the following are attainable values: total solids 3,000–4,000 p.p.m., suspended solids 1,000–2,000 p.p.m., B.O.D. 1,000–2,000 p.p.m., volatile acids 2,000–3,000 p.p.m.

Intermediate and end products of liquefaction and gasification of the digesting sludge find their way into the supernatant liquor. These are either in soluble or colloidal forms. During the period in which liquefaction predominates, the quantity of the intermediate products such as volatile acids and colloidal material in the supernatant liquor is high. As the digestion nears completion, most of these products are destroyed, leaving only the relatively resistant materials in the liquor.

The ideal supernatant liquor as described above is not always attained; complete separation of the liquid from the sludge does not always take place in the digestion tanks. Under very aggravated conditions there is little difference in the percentage of solids vertically in the tank. Under less aggravated conditions the liquor may represent a thin sludge with 1 or 2 per cent solids. Naturally, the type of disposal of the supernatant liquor will depend on the nature of the liquor.

When the supernatant liquor approaches the values given above, returning it to the influent of the plant will have no appreciable effect on the subsequent treatment processes, even with the activated sludge process, especially if the return of the overflow is spread over the entire day. Supernatant liquor which is more like a thin sludge should not be returned to the influent of the plant, but disposed of in lagoons on sludge drying beds or chemically treated.

The special treatment of supernatant liquor by atomizing aeration and subsequent settling has been reported to reduce the original B.O.D. from 1,500 p.p.m. and the suspended solids from 2,200 p.p.m. down to values found in normal sewage. But more results with supernatant liquor with still higher values would be required to establish the value of this treatment.

Wide fluctuations occur in the nature of the supernatant liquor at the same plant at different times, as well as at different plants. One of the factors is whether secondary sludge, especially activated sludge and to some extent humus sludge, is digested together with primary sludge in the digestion tanks. It seems that the gelatinous nature of activated sludge is not readily destroyed by digestion, hence making it difficult for liquid to separate from the sludge. The concentration of liquefied colloidal and soluble materials in the liquor will depend, among other things, on the concentration of the digesting solids. It is reasonable to assume that a thicker sludge will throw into the liquor more products than a thinner sludge, if everything else is equal. When the loading rate into the digester is high, it is to be expected that the greater gas produced per unit volume of tank capacity will stir up the tank contents and prevent the separation of the liquor. Pumping sludge with high moisture content into the digester will reduce the detention time for supernatant liquor, giving rise to poor quality overflow. Increased temperature from 70° to 95° F. has no appreciable effect on the quality of liquor. In unheated tanks, however, when the temperature rises in the summer, effects similar to overloading are obtained due to violent gas evolution from the partially digested material accumulated during the winter months. Two-stage digesters are designed to segregate the active digestion period, with its concomitant high rate of gas evolution and stirring up of the sludge, from the more quiescent storage conducive to compacting of the sludge and separation of the liquor.

SEWAGE SLUDGE AS A FERTILIZER*

By A. H. Niles

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Many new operators of sewage plants have been amazed at the lush growth of garden produce which sprang up as volunteer plants around their sewage works, many times growing in the partially dried sludge cake undiluted with soil. This probably occurred most frequently with tomato plants, and as they grew, it was noticed that they were much sturdier, the color of the foliage was of a much deeper green and the plants much larger than those which happened to grow in the surrounding soil unaffected by sewage sludge.

This new operator had only a passing interest in the appearance of these plants but as the season progressed and the fruit began to ripen, the day came when he was perhaps short of sandwiches or was long on appetite. The appearance of a particularly large and luscious looking tomato became irresistible. He had become sufficiently well acclimated to the atmosphere of a sewage treatment works to overcome his natural aversion to the thought of eating a fruit or vegetable which was fertilized directly by human feces, whether fully digested or not.

As this new operator sampled the appealing fruit, he smacked his lips and probably murmured "Hmm—not bad." From that time on he was sold, and being more or less a loquacious individual, did not wish to hide his discovery "under a bushel." He told his friends and they in turn told theirs so the story of sludge as a fertilizer began to be a matter of not uncommon knowledge. However, as in most cases of this kind, there was considerable misinformation disseminated along with the truth. Soon extravagant claims were made that sewage sludge was the universal panacea for all the ills of the agricultural world. Unscrupulous promoters claimed that sewage plants could be made self supporting solely by the sale of their sludge as fertilizer.

Farmers long had believed that the only difference between the commercial fertilizer manufacturer and Jesse James was that the commercial product gave no visible evidence of the company having horses, and the salesmen usually did not wear spurs. Soon the commercial fertilizer companies were worried to the point where they were putting out their own brand of propaganda. These statements were that sewage sludge was of such low value that it was not worth hauling home or spreading on the fields even if given to them. Also, that it was full of disease producing bacteria and the user of the produce would certainly contract horrible afflictions or death. As is almost universally the case, the truth, probably, lay somewhere between these two widely divergent viewpoints.

* Presented at 20th Annual Conference, Michigan Sewage Works Association, East Lansing, April 5–6, 1944.

The writer, being of Welsh extraction, which, according to some, is a Scotchman raised to the *n*th power, felt that it was economically wrong to throw away anything of demonstrated value. When the Toledo sewage treatment plant was started, it was decided to give the sludge away for a limited time for advertising purposes. This was all right except for the fact that a few persons obtained sludge which was insufficiently dried. When this was spread upon their lawns and their small children ran across the yard and tracked the sticky mess into the house, their irate mothers promptly consigned the sludge and all persons connected therewith to the place where sludge drying could be most economically accomplished. These unfortunate incidents, together with the psychological fact that, to many persons, anything obtained "for free" has no value, gave the sewage sludge program somewhat of a setback before it really got under way.

However, a start was made with an attrition mill borrowed from a miller friend. It was not well suited for the purpose but did a passably good job. This was followed by a threshing machine concave and that in turn by a light farm hammer mill primarily suited for grinding grain and feed. Quite a lot of tonnage was put through that old farm mill and the product packaged in used calcium chloride burlap bags obtained from the Street Division. This package was an unattractive one and, besides, its printing indicated that it contained a product to lay dust or melt ice instead of to grow plants. It was sold to the relatively few persons who had previously used the free sludge and were sufficiently pleased with the results to part with real money. This was especially noteworthy because it occurred at a time when pocket books were flat—when the C.W.A. leaf raking program was at its height and national budgets were ending with 6 zeros instead of 9.

Finally, in 1937, a W.P.A. project was approved to construct a plant to prepare economically the dried sludge for fertilizer and a warehouse to store it in. A contest was initiated in June, 1938, to name the child formally. Many names submitted were not thought usable because of being too expressive, but as a final result, the infant was christened "Tol-e-Gro." Its godfather was rewarded by a handsome prize of 10 bags of the material—a part of which he promptly gave away to his close friends and neighbors.

A multiwall paper bag, printed in 2 colors with analyses and complete instructions for use, was adopted together with modern equipment for preparing, bagging and handling. A modest newspaper advertising program was inaugurated and a salesman hired for two seasons to get the merchandising campaign under way. Most of this took place in 1938 and 1939. Since that time the only advertising done has been the printing of folders used by dealers to acquaint their customers with Tol-e-Gro. No salesman has been needed since 1939, for every bit of Tol-e-Gro that could be dried has been sold. In the spring of 1943, at least 250 tons more could have been sold if it had been available.

Just about this time, the fall of 1937, the Toledo plant had the good fortune to obtain a chemist who had the background, the training, the energy and the inquisitive mind to do a good job of research. His assignment was to find out what made sewage sludge "tick." It is the purpose of this paper to tell you some of the things he found out.

First of all, from general observation, it was assumed that sewage sludge had something that promoted growth other than the amounts of nitrogen, phosphoric acid and potash that could be determined from analyses in the chemical laboratory. All that is necessary to confirm this observation is to read the history of China. The Chinese have used their waste products—human, animal and vegetable—for centuries as fertilizers. Their lands are still among the most fertile in the world. Chemical fertilizers were unknown to these uninformed people, yet they maintained the fertility of their land. Their country was too crowded to move to more fertile, virgin fields. It was absolutely essential that they maintain their soil fertility. To do so they used the above mentioned wastes, putting them back into the soil. In Europe, the farmers of today will not tolerate the waste of manures—even human manure is carefully used for fertilizer. These farmers, undoubtedly, knew very little and cared less about how much nitrogen, phosphoric acid and potash were in their wastes. However, they did know that these wastes were what their ground needed to keep it fertile and productive. These manures and natural wastes actually were poor fertilizers if compared analytically with some of the so-called complete fertilizers, such as 4–12–4 or 5–10–10, etc.

It is true that these chemical fertilizers are giving good results. But is it not reasonable to believe that these natural wastes must have something in them or their action which makes them better fertilizers than the straight analysis of nitrogen, phosphoric acid and potash would indicate? No one can make up a standard mix commercial fertilizer with the same analysis as Tol-e-Gro which is 2.0–2.0–0.30, and come anywhere near to obtaining the results that can be obtained by using Tol-e-Gro or a barnyard manure with a similar analysis. Immediately, it will be said that the organic form of nitrogen is of longer duration and the plant fed more continuously, but that again is not the whole story. The purely chemical analyses in the laboratory do not show the countless billions of little nitrogen fixation factories found in sewage sludge and manures which take nitrogen from the air and convert it to the form of nitrogenous compounds easily assimilable by the plant life. Tol-e-Gro contains enormous numbers of nitrogen fixation bacteria which are found in some soils in limited quantities but not in all soils. Their presence is conducive to good fertility. These bacteria are collectively known as Azotobacters and Nitrobacters. These microorganisms have the power of transforming the nitrogen in the air to useful compounds which can be assimilated by plants for food. They not only make nitrogen more available to plant life but they also attack and break down humus, straw, old dead roots and other organic substances in the soil, to useful, life giving stimulating compounds used by the plant life.

It was found that Tol-e-Gro will increase its nitrogen by 20 per cent in 7 days if moistened and allowed to stand exposed to air. This nitrogen in the air is changed to ammonia and nitrates which are eagerly taken up by the plants and utilized in their normal metabolism. The Texas Experimental Station Bulletin No. 445 states that similar sewage sludge mixed with samples of different kinds of soils produced from 64 to 134 parts per million of nitrate nitrogen. This is more nitrate nitrogen than is produced in some higher analysis fertilizers. This variation is due largely to the variation of soils rather than to the sewage sludge itself. Since a medium or normal nitrate soil will show 5 to 15 parts per million, according to Michigan Technical Bulletin No. 132, it is obvious that sewage sludge gives an abundant supply of nitrate nitrogen. Quoting from the above Bulletin No. 132, "The nitrogen of the soil organic matter is transformed to ammonia and then to nitrites and finally to nitrates by means of the action of soil organisms. This process is known as nitrification. In order for a soil to form nitrates naturally, it should have a supply of nitrogen in organic matter, be moist, warm and aerated and have the nitrifying organisms present. Soils low in organic matter are usually low in nitrate and nitrifying organisms. Growing plants obtain most of their nitrogen from the soil as nitrates."

Nitrates are water soluble and, unless protected by organic matter, are easily washed through the soil. Tol-e-Gro supplies an abundance of these nitrifying organisms as well as a good reserve supply of organic matter and prevents leaching of valuable nitrate salts from the soil. The amount of ammonia in the soil is dependent upon the same factors as nitrates, that is, abundance of organic matter and nitrifying organisms. Chemical salts used on soils are easily leached out by heavy rains and partly wasted as far as soil nutrition is concerned.

The use of sewage sludge or manure will, in a large measure, control this leaching as it will hold many times its volume and weight of moisture, thus keeping the dissolved nutrients in contact with roots for a much longer time than would otherwise be possible.

Most sewage sludges have a residual or reserve property of releasing food as the plant needs it. These organisms will make just a certain amount of excess ammonia or nitrate which is more than the plant needs. They cease production of these nutrients and cease their activity until the nitrate concentration falls somewhat. Then the nitrifying bacteria start making more ammonia and nitrate from the air. Thus, there is always available an ample supply of usable nitrogen.

Sewage sludges and manures are helpful in making heavy clay soils porous and workable. Sandy soils are helped by the humus present in sewage sludge and by the moisture holding properties of the sludge. Sandy soils are almost always deficient in nitrifying bacteria and certain colloidal conditions which are essential to plant growth. Tol-e-Gro supplies the soil with micro-organisms and helps correct these colloidal deficiencies.

Many elements are essential to plant growth other than nitrogen, phosphorus and potassium. Many crops have been thoroughly analyzed to find just what elements are needed in their growth. Analyses were made of corn, wheat, sugar beets, alfalfa, tomatoes, barley, rye and cabbage, as reported in *New Agriculture*, April, 1937. The following elements were found to be present in the above crops: nitrogen, phosphorus, potassium, calcium, aluminum, arsenic, barium, beryllium, boron, bromine, chlorine, chromium, cobalt, copper, fluorine, iodine, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, rubidium, silicon, silver, sodium, strontium, sulfur, tin, titanium, vanadium and zinc. This totals 33 elements in all. Of these elements, 22 are present in in corn; 26 in wheat; 20 in sugar beets; 27 in alfalfa; 22 in tomatoes; 14 in barley; 15 in rye; and 22 in cabbage. Therefore, it seems reasonable to assume that a good fertilizer should include more than just nitrogen, phosphate and potash. Tol-e-Gro shows the presence of 29 of these various elements.

Sewage sludge has an abundance of mineral elements, many of which are present in such forms as to be slowly and sufficiently available to plant life. Since about 30 different minerals are being constantly taken from the soil by crops, it seems reasonable that replacement of many of these elements is advisable.

A composite sample of 325 tons of Tol-e-Gro was carefully collected and analyses made of same sample. These analyses are quite complete for all common mineral and non-metallic constituents, and the results are expressed in pounds per ton of Tol-e-Gro:

Nitrogen	42.4 lbs.	Copper	16 lbs.
Phosphoric Acid	40.3 lbs. (plus)	Iron	76 lbs.
Potassium or Potash	7.0 lbs.	Aluminum	72 lbs.
Silicon	146.0 lbs.	Zinc	20 lbs.
Lead	15.0 lbs.	Arsenic	2 lbs.
Calcium	94.8 lbs.	Barium	1 lb.
Calcium equivalent in limestone	236.8 lbs.	Sulfur	65 lbs. (plus)
Magnesium	22.0 lbs.	Manganese	12 lbs.
Magnesia equivalent	36.5 lbs.	Bismuth	12 lbs.
		Chromium	5 lbs.

Traces of tin, molybdenum, selenium, lithium, cobalt, nickel, iodine, bromine, undetermined amounts of chlorine, titanium, fluorine, boron and sodium. These last 5 elements are present in decidedly more than traces. Spectrographic analysis confirmed these trace elements. The organic portion of the sample amounted to 888 lbs. per ton.

It is fitting at this time to take up some of these various elements showing in some measure just how and why they are vitally important in the metabolism and growth of plants.

Aluminum is essential to plant growth. It is usually present in soils in sufficient quantity although it may be deficient in sandy soils.

Along with the organic matter in the soil, aluminum is active in controlling the colloidal functions and water conserving properties of the soil.

Arsenic. The following statement is taken from *New Agriculture*, April, 1937 issue: "Although formerly believed to be toxic in certain concentrations, it has proven beneficial and stimulates the growth when present in small quantities. As much as 1000 lbs. per acre have not proven toxic in experimental work." Dr. J. E. Groves, of Utah, says, "Arsenic stimulates bacterial action in the soil resulting in greater crop yield." He further states, "Arsenic must be applied in enormous amounts before it retards microscopic life." Experiments show that arsenic causes liberation of insoluble elements in the soil, especially phosphate.

Barium is found in varying amounts in some plants. It is believed to prevent injury from excessive concentrations of other elements. However, there is not much known about the value of barium except that it is found in the structure of some plants, namely, corn, wheat, sugar beets, alfalfa, tomatoes and cabbage.

Boron. Much work has been done on the influence of boron on plant growth in the last 20 years. Warington (1923) and Breachley (1927), at the Rothamsted Experiment Station, believe that boron is essential to plant growth and this belief is concurred in by Sommer and Lipman (1926), Johnson and Dove (1928) and others in this country. Collins (1927), working at the New Jersey Experimental Station, found that boron did have a stimulating effect when present in small quantities.

Calcium is one of the very essential elements. Non-legume crops will require at least 25 lbs. per acre while legumes, alfalfa, clover, etc., will require 100 lbs. and more per acre. Most soils, it is true, have calcium in their make-up but it is not always in an easily available form. Calcium, more or less, controls the acid and alkaline balance in the soil. It has a controlling influence on the translocation of sugars and starches in the plant. It is essential to the construction of healthy cell wall of plant tissue.

Chlorine is apparently useful to plants in small quantities. It seems to have a catalytic effect and tends to make other elements more available.

Copper has been found in many plants and it appears to be essential for sun flowers and tomatoes. Copper gives good results, especially on wet, boggy lands where most minerals have been leached out of the soil. Copper, along with manganese, has decidedly beneficial results with carrots, radishes, beets, cabbage and other garden crops.

Cobalt, in small quantities, has been found to stimulate crops. It has been found to be important in tomatoes, wheat and corn culture (*New Agriculture,* April, 1937).

Magnesium is as essential to plants as phosphorus or potash yet, until recently, experimental stations and fertilizer industries have paid little attention to the possibilities of a magnesium hunger or magnesium fertilization. Most plants will show from 5 per cent to 10 per cent magnesium oxide in their ash. Magnesium is a constituent of the chlorophyll molecule. It is absolutely necessary in the production of a healthy green color in plants. Magnesium plays an important role in the translocation of starches in the plant. It is an essential factor in the formation of vegetable fats and oils and functions as a carrier of phosphorus in plant metabolism. Bartholomew (1933) has gained evidence showing that soluble magnesium in plants increases the absorption of phosphorus. Cooper (1930) found that magnesium is desirable for resinous plants. Sewage sludge carries large amounts of easily available magnesium. Loew (1901) showed that for the best development of most common field crops the soil should have a calcium-magnesium ratio of 2 parts of calcium to 1 of magnesium. During wet seasons magnesium is easily leached from the soil. The combination of magnesium with organic material is, therefore, highly desirable as the organic material helps prevent excessive leaching.

Iron is very essential but most soils contain sufficient amounts for normal growth.

Manganese is a constituent of nearly all field and garden crops. It is now considered to be one of the essential elements for normal growth. McHargue (1926), of the Kentucky Experimental Station, demonstrated conclusively that manganese was essential for plant growth. Manganese appears to be necessary in the normal oxidation reactions taking place in plant metabolism. Addition or incorporation of manganese in fertilizers to be used on alkaline soils or soils underlain with lime, is important, as the alkalinity reduces the availability of manganese. Therefore, alkaline soils are apt to be deficient in available manganese. Manganese deficiency is due, largely, to the increasing scarcity of manure. Manure usually contains sufficient manganese for most soils. Sewage sludge contains an abundance of manganese, even more than manures, and is a very good carrier of manganese for fertilizer use.

Sodium is easily leached from soils and should be replaced. Beets, mangoes, potatoes, wheat, barley and asparagus respond quickly to the presence of sodium salts in the soils. Some experimental stations are using top dressings of sodium chloride, or common salt, with remarkable increases in crops. Sodium seems to help conserve the phosphorus and potash and help the normal reactions in the plant.

Sulfur was proved to be an essential element to plant growth in 1860. Sulfur is a constituent of many plant proteins, cereals, etc. Sulfur is a constituent of plant flavors and aromatic oils and is a constituent of mustard oil, onions, garlic and many other flavors more pleasant. Many plants require more sulfur than phosphorus (*Commercial Fertilizers,* Collins—1934).

The annual loss of sulfur, through drainage, is estimated at between 20 and 50 lbs. per acre. Many plants will respond remarkably to sulfur. Alfalfa will respond to sulfur even better than nitrogenous fertilizers. Cases of alfalfa increases, with sulfur carrying fertilizers, have been reported from 50 to 500 per cent. Sulfur increases root growth in most plants (Crocker—1933). Garden crops, such as cabbage, lettuce, radishes, beans, peas, etc., respond readily to sulfur.

Tol-e-Gro contains sulfur bacteria which change insoluble forms of sulfur to soluble sulfates which are available to plants. Tol-e-Gro is rich in sulfur—65 lbs. per ton.

Small amounts of zinc seem to be important to plant life as zinc is found in almost all of the common crop plants and fruits. Zinc controls mottle leaf and rosette in fruit trees.

Users and experimenters of sewage sludge as fertilizer have repeatedly called attention to the fact that results obtained by using Tol-e-Gro and some similar products are far better than the nitrogen, phosphoric acid and potash analysis would indicate. The importance of other mineral constituents has been shown, in a small way. Taking all these minerals into consideration, the results obtained by using Tol-e-Gro are still beyond those expected from the straight, routine, standard analysis.

This may be partially explained on the basis of increased moisture holding capacity; the change in soil structure, allowing more air to enter and subsequently stimulating oxidation; introduction of large numbers of bacteria to aid decomposition and better balancing of the nitrification processes and flora of the soil.

It has been found in running laboratory comparative tests that plants grown with Tol-e-Gro had two or three times the root growth of plants grown under identical conditions with commercial 4–12–4 fertilizers. Also, comparative tests with potatoes grown on good loam soil resulted in a 200 per cent increase for hills fertilized with Tol-e-Gro at the rate of 400 lbs. per acre. The root growth was noticeably greater and the potatoes were larger. A search was started to determine in some measure the cause of these fine results and increased root growth. In recent years considerable attention has been focused on the fact that certain organic compounds or chemical substances are able to increase root growth and stem elongation and to influence changes in plant growth. It was in this direction that the search was started.

It is well known that in the presence of nitrifying bacteria, such as Azotobacter Chroococcum, something was formed which induced increased root growth. As previously stated, Tol-e-Gro is virtually alive with nitrifying bacteria. It has been shown that these growth promoting substances are probably not made by the bacteria but are produced as bacteria break down the organic materials upon which they feed. Tol-e-Gro is rich in these organic substances. This explained, in part, the origin of these chemical substances but the next thing was to demonstrate their presence and approximate the amounts present. These substances were found to be present in small quantities when expressed as pounds per ton, but this is more than sufficient when compared to the requirements for plant stimulation. These substances were identified as derivatives of indole, a complex organic chemical.

Dr. Willem Rudolfs, head of research of the New Jersey Agricultural Experiment Station, Dept. of Water and Sewage, together with Messrs. Heineman and Ingols, reported in SEWAGE WORKS JOURNAL, Volumes 10 and 12, on various growth promoting substances found in sewage sludge. Their conclusions were that most growth promoting substances found in sewage sludge were from indole and skatole in the form of indole acetic, indole propionic and indole butyric acids. Tryptophane is also formed by digesting or decomposing sludge. Carotene and ascorbic acid are present in limited quantities.

Many of these substances are soluble and tend to wash or drain out of the digesting sludge. It was found that concentrated filtrate collected from the underdrainage system of the glass covered sludge drying beds at Toledo was far more potent in growth promoting substances than the dried sludge. This corroborated the statement heard many times that "the best part of sludge is drained away."

Damoose at Battle Creek, as did Backmeyer at Marion, Ind., found this to be the case when they advocated using, and actually sold on an applied basis, quite large amounts of liquid digested sludge. This method of use certainly has its limitations but, where possible to handle it economically, it produces wonderful results. For years, Hommon at Canton, O., has disposed of liquid digested sludge directly to a city owned farm adjacent to the sewage treatment plant, with phenomenal crop yields.

In conclusion, it may be summed up that, measured by purely chemical analyses, sewage sludges do not compare very favorably with many commercial fertilizers. Sewage sludge probably never will drive commercial fertilizer companies out of business. Many of these companies do use sewage sludge as a base and fortify it with additional chemicals to gain the analysis desired. This, in part, gains for the commercial fertilizers some of the advantages sewage sludges have.

However, even the worst critics of sludge, unwillingly, perhaps, admit that it has some properties that give plants an "oomph" that a standard commercial fertilizer just does not have.

EMERGENCY LAND DISPOSAL OF SEWAGE *

By William J. O'Connell, Jr., and Harold Farnsworth Gray

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The subject of "Emergency Land Disposal of Sewage" has been selected for discussion at this second War Conference of the California Sewage Works Association because there is need for consideration of emergency means of disposal of sewage and industrial wastes where population and industrialization have increased beyond all predictions, and where present conditions make it impracticable or impossible to obtain critical materials or equipment necessary for enlargement of existing plants on a conventional basis.

In addition, there is need for a simple and quickly constructed means of treatment and disposal if a treatment plant is put out of operation by sabotage or other enemy action.

The subject has also been selected for discussion at this meeting because it is of direct interest to the operators of 103 out of 351 municipal plants listed by the United States Public Health Service in a recent survey of such facilities, as summarized in the following table, and is also of a direct interest to the operators of at least 50 out of more than 100 plants at institutions and military establishments where land disposal or lagooning of settled or pre-treated sewage is used as a final treatment step.

Number of Installations according to Population Served

Type of Land Use	0 to 2,000	3,000 to 6,000	6,000 to 15,000	15,000 up
Application to land without cropping	40	13	6	1
Application to land with cropping	24	9	8	2
Totals	64	22	14	3

Since about one-third of the operators of sewage treatment plants in California are concerned with problems associated with these disposal methods, a reasonably adequate attention to the subject may be considered to be long overdue.

Roughly about one hundred of these plants, serving in excess of 400,000 population, use some form of land disposal as a treatment or disposal process, and of this number about 43 plants, serving in excess of 90,000 population, use treated effluent for irrigation of crops.

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General Discussion

Wars invariably affect the whole people, and to greater or less extent modify all manifestations of communal existence. Operators, managers and designers of sewage treatment facilities are no exception to this obvious statement, and are frequently hard put to it to meet the changed conditions which impose new demands, quantitatively and qualitatively, upon their works.

This war is characterized by a tremendous shifting of population and of industries. Cities whose sewage disposal facilities have been reasonably adequate in normal times suddenly find their disposal and treatment facilities badly overloaded, either in quantity of flow, or in oxidation requirements, or both, and some practicable remedy, even if only for the duration of the war, is urgently needed. Allocations of critical materials required in complex mechanized sewage treatment plants are unavailable or practically unobtainable, and properly so. Therefore, a relatively unmechanized method of sewage treatment and disposal is urgently needed to help solve difficult, immediate and insistent demands. Land disposal offers a simple, prompt and practical answer in many cases.

There is also another type of war problem to be considered. This is the emergency disposal of sewage due to a breakdown of equipment or plant. The breakdown may be either normal, due to ordinary wear and tear under usual operating conditions, or extraordinary, due to enemy action. In the first case, the difficulty in making repairs, or getting replacements, or in improvising repairs or equipment, due to materials priorities or shortages, may make some emergency treatment or disposal method absolutely necessary. In the second case, either through sabotage or bombing, the plant may be put out of action and an alternate or substitute method becomes necessary at once.

In these cases, land treatment or land disposal of sewage, if planned for in advance of the possible emergency, and then properly constructed and operated, offers an effective and relatively rapid solution to the problem.

However, land treatment or land disposal of sewage, is not merely an emergency or supplemental method of treatment and disposal of sewage and industrial wastes. In the authors' opinion it is a legitimate, effective and practicable method of treatment and disposal of sewage and industrial wastes under conditions to which it is especially adapted. It is our intention in this paper to try to point out the basic principles of the process, to indicate its adaptability and limitations, and to present the fundamental factors in successful operation and design.

In the first place, let us make certain distinctions in terms. We may (1) treat sewage in various types of plants to various degrees of clarification and oxidation, and then dispose of the effluent onto land or into water. Or we may (2) treat screened sewage on land, with or without primary clarification in conventional sedimentation tanks, and then dispose of the effluent either into water or onto land. Or (3) we may use land disposal on a seasonal basis, discharging the waste into an available waterway during periods of adequate flow for satisfactory dilution, and discharging the waste onto prepared land during periods of low flow and inadequate dilution in the waterway.

In the first place, we are disposing of a treated sewage effluent on land, either beneficially or otherwise; in the second case, we are actually treating (oxidizing) sewage on land. Oxidation of organic sewage substances can be accomplished in relatively shallow ponds through fundamentally the same principle as in the case of trickling filters or the activated sludge process.

In the trickling filter we expose a relatively thin film of sewage to, on one side, a biologically active zoögleal mass which is supported by the stones, and to atmospheric oxygen on the other side. In the activated sludge process we circulate a biologically active flocculent filter substance, together with air bubbles, through the sewage. In treatment on land we either (1) develop biologically active organisms in successive ponds, with oxygen absorption at the water surface, or (2) in intermittent application of sewage to the soil we obtain oxidation through biologically active organisms in the soil, plus oxidation through the air-water surface.

In treating sewage (except in those cases which are complicated by certain types of industrial wastes such as acids), we are dealing principally with rather complex organic materials, which are subject to biological or biochemical actions of various kinds, as well as to certain purely physical actions. These organic materials are in very dilute suspension or solution in a vehicle of water. But regardless of the method of treatment, or of the biological or physical processes involved, fundamentally the end result is that both the water vehicle and its dissolved or suspended materials are disposed of either onto land, into bodies or streams of water, or into the air.

Disposal into the air may represent a substantial part of the disposal of both sewage solids, and of the liquid (water). In anaerobic digestion an appreciable part of the solids is converted into the gases methane, carbon dioxide, hydrogen and nitrogen, together with certain volatile compounds such as the odorous mercaptans. A rough calculation on the basis of measured gas production from known weights of sludge indicates that 35 per cent more or less by weight (on a dry basis) of primary sludge may be converted into gas, and so ultimately be disposed of into the atmosphere.

Under some conditions the disposal of the water in sewage into the atmosphere may be a significant factor. Of course, there is a certain amount of evaporation from the sewage surfaces in sedimentation tanks, aeration tanks, and the like, but this is a relatively small percentage. Where sewage is disposed of onto land by intermittent application on shallow beds, the amount of evaporation must represent an appreciable percentage of the total amount of water applied, though we have little if any accurately measured data on this point. The actual percentage disposed of by evaporation will depend on a number of factors, with high wind velocity, high temperature and low humidity tending to increase evaporation, while highly porous or absorptive soils will tend to reduce the amount of water available for evaporation.

In arid or semi-arid regions disposal by evaporation may, under reasonably favorable conditions, take care of an appreciable percentage of the total volume of water. Under ponding or lagooning methods, a conservative figure for evaporation in central California would be five feet depth of water per year. For one acre of ground, assuming a sewage flow of 60 gallons per capita per day, this represents the disposal of the sewage of about 75 persons by evaporation alone. Under intermittent application of sewage effluent to land, the rate of evaporation may be more than double this figure, though the total annual disposal by evaporation may not be any greater.

Disposal of the water in sewage by percolation into the ground is influenced by many factors, of which the porosity of the soil and the depth to ground water, are the principal factors. For any soil the rate of percolation can be approximately determined by a simple test of applying water to a definite area of ground and measuring the time in which the water surface drops one foot after the soil has become saturated.

Disposal of sewage treatment plant effluents into water presents several aspects. In the case of large cities, or of large industries discharging great volumes of liquid wastes, this may be the only possible solution for one or both of two reasons: (1) the great quantities of water involved make any other route of disposal impracticable; or (2) there is no available land area within reasonable distance onto which the effluent can be disposed. In such case, any beneficial use of the effluent as irrigation water for agricultural purposes, or for spreading to minimize the depletion of underground water resources, may be impracticable or uneconomic.

But numerically speaking, such large plants are relatively few, and the small sewage treatment plants, so situated that their effluents and their treated sludge can be readily used beneficially for agricultural purposes, are many. Especially is this true in arid or semi-arid regions. Too frequently the small city has tried to ape the large city, by building pocket editions of the large complex plants, just to keep up with the Jones's. Neither the essential differences in conditions, nor the possible convenient uses of the small city effluent, appear to have been considered. How custom and example enslave thought!

In the sewage treatment field, the past twenty years have shown a decided trend away from simplicity in the application of fundamental principles and processes, to an involved complexity. Until the early stages of this war it definitely appeared that such thought as was given to the matter of sewage treatment fell into two main groups: (1) what mechanism could be devised or adapted for sale in sewage treatment; (2) how could the effluent be manipulated, or sludge be rerouted, or some gadget be added or changed, so that a new talking point for equipment could be developed?

But entirely aside from the concept that the simplest solution is usually the best solution, there is another aspect in the general problem of sewage disposal which needs to be considered. This is the matter of conservation. We have been a prodigal people. Our natural resources have seemed to be almost unlimited, and we have squandered them with very little thought for the future. But conditions are changing, and this war is accelerating the changes, so that on its conclusion we will have changed from a "have" to a "have not" nation in relation to some sources of raw materials, and in relation to other sources we are changing from a nation of relative abundance to a nation of relative scarcity.

In the fields of soil fertility and reasonably convenient water resources we are now in a condition of relative scarcity over considerable areas of our country. It therefore behooves us to make better utilization of waste products, such as sewage, to conserve water and to conserve fertilizer values in sewage which can be made to contribute to soil fertility and thus to a better nutritional standard for the people. It is our intention to consider the problem of land disposal and treatment of sewage partly from these aspects, and partly from a biological viewpoint.

Neither engineering, nor the older chemistry, made appreciable progress in the art of sewage treatment until Sedgwick became associated with this work through the Massachusetts State Department of Health, and through his teaching of sanitary engineers. It is a long step backward from the biological basis of sewage treatment and disposal originally laid down by Sedgwick, to the mechanistic conglomerations too often encountered today.

We will therefore try to present, on the basis of fundamental biology and physics, the essential elements and factors involved in the treatment and disposal of sewage on land, so that the information may be available not only for emergency treatment—which is our principal concern at present—but also for treatment and disposal under normal conditions after the war.

Land Disposal Types

Land disposal divides into two groupings, depending upon its purpose, as follows:

1. An agricultural operation primarily, with disposal being secondary if not incidental.
2. Disposal operation primarily, with agricultural use or employment of cropping as an incidental feature or not involved at all.

The designation "sewage farm" is used indiscriminately for either type of disposal. Because of its unsavory significance the term should be avoided. Whether agriculture is primary or secondary, or is not included, raw sewage should not be applied to the land. The minimum allowable treatment should be fine screening, and preferably should be sedimentation with a minimum detention of 1 hour, preferably 2 hours, providing a major removal of the sewage solids.

Odor Control

Whether agriculture or disposal is the primary purpose, odor control is also essential. Chemical treatment, either with chlorine or iron salts or both, should be available in the initial plant set-up.

Bad odors are an index to bad operation, however, and primary dependence should be on proper operation in applying effluent to land, rather than on heavy chemical dosages to cover up odor formation due to faulty operation. Chemical application is an adjunct, an aid to good operation, not a substitute for it. Provision for addition of chemicals should be considered in the light of a factor of safety, not as a treatment *per se.*

Prevention of odor formation largely lies in the method of application of the effluent. The soil must not be drowned out by continuous application so that oxidizing organisms in the soil are killed by anaerobic or septic conditions (sour soil). Intermittent application followed by cultivation is necessary for good soil condition (aeration) as well as to keep down weed growths. Properly operated, no appreciable odors should result from using a well clarified effluent.

Agricultural Application

If agriculture is the primary purpose, considerable areas must be available to permit use for crops, with effluent being used for irrigation only when required by crops. Essentially this means that part of the land must be set aside for disposal only, during periods when effluent is not needed for irrigation.

Best results probably will be obtained by using part of the farm as a disposal area for one year, and farming the remainder. In the next year usage of the two areas should be reversed. In this manner enrichment of soil by sewage can be rotated to affect beneficially the agriculture, and any possible danger of crop contamination avoided due to the time interval effect.

It is doubtful whether agricultural irrigation should be anticipated if the quantities of sewage that must be handled exceed 2,000 or 3,000 gal. per acre per day, and if disposal by dilution or spreading on part of the land during the winter is not also available. However, the utilization of sewage from the City of Melbourne has been worked out successfully in an agricultural operation that is the envy of most sheepmen. Melbourne sewage is transported 40 miles through an aerated tunnel into open country where it is distributed from a concrete ditch over an area of 11,000 acres. Taking the population of Melbourne to be 1,000,000 and assuming a flow of 80 gallons per capita, this appears to be a loading of around 7,000 gal. per acre per day. Land thus treated supports in entirety 400 horses, 1,500 head of cattle, and 50,000 lambs.

Land Disposal as a Primary Method

Where disposal is primary, and agriculture is not involved or is a secondary matter, the following are possible variations:

1. *Intermittent application onto prepared beds of relatively porous soil not artificially underdrained or side drained.*—In this case application may be continued for from one day to several days on one bed, but use for more than three days' application is generally undesirable. The bed is then allowed to dry out, and should be cleaned, cultivated and rested before being reused in the cycle.

The quantity disposable depends on the porosity of the soil and the depth to ground water. On a fine sand with 50 per cent voids, percolation rates of 3 inches per hour with clear water under a one foot head have been measured, but in disposing of an unclarified potato waste on this soil a 2 inch per hour percolation rate was observed (Modesto). The beds are sufficiently dry to scoop clean and cultivate in about 3 days after the effluent is shut off, and then are rested 3 more days before redosing. The effective net disposal rate is about 3 gal. per sq. ft. per day, or about 130,000 gal. per acre per day. With a coarser sand the rate probably would be greater. A fairly safe rule to follow would be to apply effluent at one-half the measured percolation rate with clear water, during a dosing period of 1, 2, or 3 days, and then to allow from 5 to 9 times as much time for drying, cultivating and resting for reaeration of the soil.

The greatest difficulty arising from intermittent application of settled or treated sewage onto prepared beds usually can be traced to overloading and insufficient cultivation of the soil. Where the soil is tight it is probable that the net loading range will lie between 2,500 gal. per acre per day and 5,000 gal. per acre per day. In the cases where prepared beds are built on fairly permeable land, the net loading range may lie between 4,000 gal. per acre per day and 15,000 gal. per acre per day. If beds are built on a sandy permeable soil formation, the load may range between 12,500 gal. per acre per day and 30,000 gal. per acre per day. In exceptional cases, where the soil conditions are ideal and a rather completely treated waste is being spread, the load may range from 25,000 gal. per acre per day to a maximum in excess of 100,000 gal. per acre per day.

However, under conditions where especially good operation is available, with frequent working of the soil, the foregoing rates have been considerably exceeded.

At Decoto, California, the settled sewage of about 3,500 population is disposed of on about six acres of beds, which are used in rotation, only about one-half the beds being used during one year. The unused beds have been planted to tomatoes, corn, etc.

The flow (about 30 gallons per capita per day) is about 105,000 gallons per day, and the net application rate is therefore about 35,000 gallons per acre per day. The sub-soil is a relatively unabsorbent sandy clay, with a surface soil of a clay-loam. This high loading rate is handled without difficulty. The effluent is applied to a bed for 2 to 3 days usually, and the bed is then dried, disked and rested. Only slight musty odors are noticed in the immediate vicinity of the beds, and only while moist.

The wastes from the Decoto cannery are brought to the plant in a separate sewer, and are disposed of without sedimentation on separate beds. The principal beds have an area of about 3 acres. When these beds are overtaxed, which occurs during the peach canning season, the flow is diverted to a sump and thence pumped to irrigate an orchard of about 3 acres area. In addition, unused beds in the sewage disposal area can be used, and in emergency the cannery waste can be pumped to irrigate an adjacent orchard.

Appreciable fermentation odors occur near the cannery waste disposal areas during the time of operation and for a few days thereafter while the soil is drying, but there is sufficient isolation so that no nuisance is created.

On the basis of experience at this plant it appears probable that the sewage of about 7,000 people can be disposed of safely on this site, winter and summer; but if the cannery should enlarge its capacity either some method of solids removal must be undertaken, or an adjacent six-acre property be acquired for disposal.

2. *Intermittent application onto underdrained or side-drained beds.*—Where depth to clay, hardpan or other impervious layer, or to ground water, is shallow, artificial drainage will be necessary, and in effect the soil then becomes a biological filter. Here again, in order to maintain proper oxidizing (stabilizing) balance, and to prevent serious odor formation, the beds must be dosed intermittently.

Sub-drainage by means of drain tile is a comparatively expensive matter, though justifiable in certain cases. In this case the stable effluent from the underdrains must be disposed of into a waterway, a drainway, or to beneficial irrigation use. In some cases pumping may be required.

A variation of underdrainage where there is a shallow soil depth on a hardpan sub-soil is to cause the effluent to filter laterally through comparatively broad dykes and be picked up by lateral drains outside the dykes.

The effluent which has percolated through the dyke soil into the lateral drains may be conducted to a central sump and pumped out, or possibly carried on a grade, if available, to a water-course or drainway. Again intermittent application to permit restoration of the oxidizing capacity of the soil in the dykes is necessary, and also to dry out the dykes so that weed cutting machine equipment can be used on the dykes.

At Santa Clara, California, domestic sewage and cannery wastes, pre-treated with chlorination and settled in a clarifier, are discharged to land disposal on about a 200-acre tract that for all practical purposes is divided into three sections, each section being used for a year at a time, one for disposal, one for resting, and one for cropping. When the cannery is in operation the total flow for 16 hours is 2,000,000 g.p.d.

of which the domestic flow amounts to 500,000 g.p.d., during a 12-hour period. During the canning season of July, August and September, this combined waste is chlorinated ahead of settling, using 4 tons of chlorine per month. The land disposal area is divided into a number of narrow contour beds made by throwing up banks with a ditcher. The sewage is carried to the beds through a distributing header ditch and the water spread in the beds then percolates through the banks and drains to the intervening ditches. These ditches are interconnected so that they constitute lateral collecting ditches and tie into a common collecting header, which in turn discharges to a creek that flows into San Francisco Bay. Very satisfactory conditions are maintained in this final diluting water body, without odor nuisance around the disposal area.

3. *Oxidation in ponds, where relatively little effluent percolates into the soil* (*clay formation*).—In this case there is little evaporation and a stable oxidized effluent is finally disposed of into a stream or drainway. Here we are trying to oxidize the dissolved, colloidal and fine suspended solids, and get rid of harmful fecal bacteria, but we are not eliminating or greatly reducing the volume of water. This may be termed "lagooning" and may be either relatively shallow or relatively deep.

A particularly interesting plant has been constructed at Manteca. This plant is the culmination of one of the early efforts to recognize the necessity of separating industrial and domestic flows wherever possible, and treating each portion of the total waste independently, but preferably at the same site. Domestic sewage and infiltration flows, together with 80,000 g.p.d. of cheese production and creamery waste, give a total flow in the order of 300,000 g.p.d. This combined flow is settled in an Imhoff tank and oxidized in a trickling filter, from which it is discharged to final settling basins and then to 7-1/2 acres of disposal area where the treated waste is ponded 12 inches deep. This ponding takes place on a very tight soil so that a large portion of the flow discharges from the ponds to a drainage ditch.

In addition, the flow can be diverted from the settling basins for use in irrigating 36 acres of clover and alfalfa. Fourteen head of cattle are pastured on 8 of the 36 acres so irrigated. The 7-1/2 acre ponding area is divided into about three equal sections with a number of checks, and each of these sections is used in rotation for periods of about two weeks at a time. Similarly, the two final settling basins are rotated in use on a 10-day schedule. The combined efficiency of the treatment plant and land disposal area is indicated by an 85 per cent reduction of B.O.D. Apparently the B.O.D. of the "domestic" waste is in the order of 350 parts per million; the settled flow has a B.O.D. in the order of 260 parts per million; the filter effluent around 75 parts per million; and the pond effluent 35 parts per million. The detention period in the ponds is about 8 days.

In addition, a separate industrial line carries cannery wastes to the plant site, but not through the Imhoff tank or trickling filter. This industrial waste amounts to between 350,000 g.p.d. and 1,500,000 g.p.d., and is handled on 11-1/2 acres of land set up in 13 checks. The first 7 of these checks have been modified with a cross-dyke which cuts off one-fourth of the area. This smaller area of these 7 checks can be considered as a primary settling area, and each of the 7 small sections is used in rotation for primary settling of the industrial waste. The balance of the 11-1/2 acre area is used continuously for ponding throughout the cannery season. During the period when the canneries are in operation, figures have been collected indicating that the dissolved oxygen in the ditch above the discharge from the industrial waste treatment area amounts to 2.8 p.p.m. Below the overflow this drops to 2.0 p.p.m. There is no dissolved oxygen in the cannery waste reaching the ponds, but the industrial waste treatment pond overflow nearly always shows a trace of dissolved oxygen.

Lagooning

In considering lagooning as a sewage treatment method, we have adopted certain criteria as basic.

In the first place, lagooning as an oxidizing process depends in part on the area of water surface available for aeration, in relation to the volume in the lagoon, and to the total flow.

Secondly, it is assumed that a minimum detention time of 20 days is required to eliminate pathogenic bacteria, and reduce coliform organisms to a relatively small number.

Third, we have assumed that a depth of 4 feet is desirable to get away from tule and other growths on the lagoon bottoms, minimizing operating costs.

Fourth, we have assumed a relatively impermeable soil, so that the seepage losses are negligible.

For a city of 10,000 population with a sewage flow of 60 gallons per capita per day, under these conditions the total lagoon area required is about 10 acres (slightly less) or roughly 1 acre per 1,000 population.

We have tried to calculate on this basis the oxygenation rates and total oxygen consumption through the ponds, but the conditions are so complex that we have concluded that this is impossible. We even doubt whether quantitative oxidation studies which are determinative can be carried out by the laboratory, as a stabilized and relatively safe effluent can be obtained which will still have a high B.O.D. because of green algae growths, and be supersaturated with oxygen during daylight hours.

On a twenty day basis in the lagoon, the oxygen requirement for an average of 10,000 population would be in the neighborhood of 20,000 lbs. of oxygen, or less, depending on the efficiency of the primary sedimentation.

It is probable that better results will be obtained by dividing the lagoon into three or perhaps four sections, to somewhat stratify the types of organisms at work on the oxidation process.

To minimize septic conditions in the first section, and perhaps to improve over-all oxidation, two possible applications appear to be worth trying. One is to apply chlorine to satisfy the immediate oxygen demand of the effluent, which may call for about 10–15 parts per million, or to add iron (ferrous) salt to absorb any hydrogen sulfide formed. The other would be to recirculate some of the effluent, either from the final lagoon or the third, if there are four sections. Probably the recirculation of one-half of the total flow should be sufficient, perhaps one-quarter in some cases.

Lagooning in shallow beds has been tried, but has several disadvantages as practiced. The shallow beds permit vegetative growths such as tule, and it becomes difficult to maintain clean beds; as a result the whole scheme fails and becomes a foul smelling, mosquito breeding mess. The shallow beds also require a greater area of land for the required minimum detention time of 20 days. If weed growths are dense, sunlight is cut down on the water surface and reoxygenation by algae is seriously diminished. Shallow beds of greater area, however, will permit greater evaporation loss, which may be beneficial if the effluent is simply wasted, or detrimental if the effluent is beneficially used.

Greater depths than about 4 or 5 feet may be undesirable, for several reasons, particularly because at greater depths there can be but little penetration of sunlight, and therefore the growth of oxygen-generating algae will be diminished.

Mosquito breeding in lagoons can be controlled if fish (*Gambusia affinis,* the mosquito minnow) are adapted or acclimated to living in sewage. A. M. Emerick has done this successfully in the Calistoga ponds. If fish are not used, it will be necessary to kill the mosquito larvae by spray application of a light petroleum oil such as a Pacific Specification No. 100 stove oil, which will evaporate fairly rapidly and interfere but little with oxygen absorption through the water surface. Heavy oils must not be used. Spraying may need to be done once a week in hot summer months and less often, perhaps once in three weeks, in cool weather.

Emergency Sedimentation Ponds

It is assumed that whether the oxidation and stabilization of the sewage is accomplished either in lagoons or in intermittent percolation beds, that the sewage will be at least fine screened and preferably well settled first. In case land disposal is used as an emergency disposal method, either to replace a plant put out of operation, or to supplement an overloaded plant, preliminary sedimentation can be accomplished in settling ponds excavated in the ground and not even lined. In this case, several such tanks should be provided, which can be used for one or two days each, then cut out, and the deposited sludge either pumped to a deep pit for digestion, or dug out with a power crane and clamshell bucket and transferred to an adjacent digestion pit. After cleaning, the settling ponds can be reused. In such operations chlorination will probably be desirable to minimize odors.

If lagoons are not correctly operated they can be the source of insufferable nuisance due to odor production and mosquito breeding. Such conditions as obtained when lagoons are overloaded and incorrectly operated are best pictured in colored photographs.

Soil Fertility Conservation

Limitations of time and perhaps also of the patience of the audience preclude any adequate discussion of the problems of soil fertility, the nutritional requirements of the nation, and the relation of reclaimable fertilizer values of sewage in relation thereto.

Some slight thought has heretofore been given to superficial aspects of this matter at previous meetings, and we believe it to be sufficiently important to be given more attention at future meetings of this Association. For assuredly we are facing a crisis in national nutrition, and there is more than a mere prospect of a serious deficiency in food supply ahead of us as this war proceeds.

The whole subject is most complex, and involves not merely the quantitative nitrogen, phosphorus and potash requirements of crops, but also the more elusive yet highly important problems of vitamin deficiencies in food products due to soil impoverishment in organic constituents.

For those who wish to pursue this line of thought we suggest, as a valuable starting point, the study of a paper by W. A. Albrecht of the University of Missouri, published in *Chemical and Engineering News*, February 23, 1943, and entitled "Soil Fertility and the Human Species."

Wars have a habit of breaking up rigid mental processes, and shaking us out of our stereotyped ideas. Possibly if under the compulsion of war the relatively simple, unmechanized emergency treatment and disposal of sewage on land is shown to be practicable, effective and satisfactory, and relatively inexpensive, it may also be found to be worth considering in normal design and in particular in conjunction with properly directed farming operations, all under one management.

Discussion

By C. G. Gillespie *

This discussion will confine itself to the idea of lagooning of sewage, in which percolation is no factor at all; in fact, as percolation and evaporation exceed the inflow, lagooning is not even possible.

There are now in California at least 25 places where lagooning of sewage is used purposely for its natural purification properties. Tests for dissolved oxygen, B.O.D., and sewage organisms and absence of bad odors show beyond doubt that with conditions right for algae action, this cheap expedient is valuable in correcting nuisance and stream pollution.

* Chief, Bureau of Sanitary Engineering, California State Dept. of Public Health.

You may be interested in a list of places employing lagoons as a treatment process. Places which use or have utilized lagoon action without any other treatment of sewage include Gustine, Merced, Yuba City and Sacramento.

Places which use or have used septic tank treatment ahead of lagoons are Sonoma (abandoned), Vacaville, Fresno, Oakdale, Pleasanton, Santa Rosa and St. Vincent's Orphanage near Santa Barbara.

Places treating the sewage with Imhoff tanks or plain clarifiers with or without mechanical equipment include Calistoga, Coachella Sanitary District, Sebastopol, Ukiah, Galt, Imperial, Thermal Ground Crew Base, Bicycle Lake Bombing Base, Douglas Aircraft Modification Center, and Stockton.

Places employing the lagoons as an adjunct to some form of oxidizing treatment, usually to gain in bacterial protection, include U. S. Reclamation Service Headquarters at Shasta Dam, and at Friant, San Juan Bautista, Loma Linda Sanitarium, Santa Barbara General Hospital, Lakeport, Minter Field, Fresno Army Base, and Merced Army Base.

A review of the literature indicates that sewage lagoons are not altogether unknown. For example, Willem Rudolfs in *Engineering News Record,* August 19, 1927, describes the fish pond treatment at Munich. With 8 million gallons a day of sewage, only 17 acres of ponds 3 feet deep are used. This would indicate probably over 200 pounds of B.O.D. per acre foot, which in our experience is 5 to 10 times higher than we would think of loading lagoons. The retention time at Munich would be only a couple of days, contrasted with 10 to 30 or 40 days in our lagoons. Yet, fish life is supported in these ponds. *Engineering News Record* of November 12, 1936, also describes a 14-acre lake at A. & M. College, Texas, which is used to supply oxygen to sewage at the rate of 50 pounds per acre per day. Average depth is understood to be about 6 feet. The article gives a continuous performance record for a whole year, indicating a B.O.D. in the final effluent of as low as 10 to 20 p.p.m. in winter, and as high as 80 p.p.m. in the midsummer.

A particularly striking illustration of the benefit of lagoon action in reducing typhoid germs comes from Java, where typhoid is so rampant; typhoid organisms are an index organism. Engineer Riis of Java reports the country is so poor that only the cheapest forms of sewage treatment can be considered, and sewage ponds are commonly used. Raw sewage contains from 1 to 41 typhoid germs per cc., the settled sewage 1 to 6 per cc., and pond effluent is negative for typhoid.

Waterworks and Sewerage for June, 1935, contains an article on the results of algae activity, some familiar, others obscure, by W. C. Purdy, U. S. Public Health Service. The article calls attention to the great natural solution of oxygen in polluted streams rich in algae, which many times exceeded the atmospheric aeration effect of wave action, ripples, or rapids. The oxygen produced by the algae was so finely defined and possessed such marked solution pressure as to be many times more effective than oxygen solution through natural aeration.

The history of how the idea of purposely lagooning sewage for its purification powers arose in California is interesting. Santa Rosa, the birthplace of the septic tank in this State, was also the birthplace of this lagooning of sewage, though it was by mere chance that the purification powers were first realized here. Lagoons at Santa Rosa came about through the search, about 1924, for an escape from the cost of a $165,000 activated sludge plant. It was known that the ancient channel of Santa Rosa Creek lay just under the sewer farm and some of the members of the City Council thought to uncover the gravels and soak into natural filters what was then polluting Santa Rosa Creek. Hardly more than 1.5 acres of "gravel" beds were exposed and they soon sealed tight and became so many acres of impounded sewage water 3 feet deep. It was quickly noted, however, that the escape or final overflow was markedly superior to the inflow and resembled trickling filter effluent in appearance. It had no odor and it was easily disinfected. It has since been found that the acreage of ponds in that case was much too small for continuous effectiveness.

In 1924, the town of Vacaville was also in jeopardy over escape of sewer farm water to a certain dry gully that ran through some neighbor's property. The City Engineer proposed to impound the summer flow and release it only in winter. The septic tank effluent here and the sewer farm were extremely odoriferous, and, of course, there was a question of what these lagoons would be like. In this case, Frank Bachmann, now one of the high officials of the Dorr Company, and at that time chemist for the Bureau, had observed the radical purification and increase in dissolved oxygen due to the filter action among the grasses of the sewer farm. The Bureau, therefore, consented to the new idea of impounding this overflow. Results of the impounding at that time confirmed the purifying property of lagoons which had been suspected at Santa Rosa. For instance, D.O. in the lagoon ran 7 to 15 p.p.m., and B.O.D. ran only 12 to 30 p.p.m. There were even some nitrates. B. coli in the ponds ran from 1 to 50 per ml., whereas the applied sewage contained better than 100,000 per ml.

The third case was at Sonoma. For several years prior to 1929, the City had been bombarded by complaints on account of sewer farm odors and creek pollution. Failing in an election attempt to run a sewer to tidewater, the city engaged E. J. Helgren, City Health Officer of Santa Rosa, to devise lagoons similar to those of Santa Rosa, but with several improvements in the way of greater flexibility of use. The Bureau studied these lagoons at considerable length while they were used. For a population of 750, there were 8 acres of ponds 12 to 18 inches deep, yielding about 20 days nominal storage, assuming no percolation. B.O.D. was reduced from 150 to 20 p.p.m., and B. coli was reduced from over 100,000 per ml. to less than 100 per ml., D.O. in the effluent ran from 4 to 14 p.p.m., and the septic tank odors had disappeared. Ultimately the lagoon system failed here by reason of excess organic matter when a winery, a cannery, and a milk plant operated together and the sewer was ultimately run to tidewater.

In the same year, the City of Calistoga was prevailed upon to convert its sewer farm into a lagoon system to overcome odors and pollution of Napa Creek. Bureau tests in 1930 indicated D.O. from 9 to 17 p.p.m., and B.O.D. from 26 to 50 p.p.m. Reduction of B. coli was from over 100,00 to 25 per ml. In fact, on some occasions B. coli was as low as 2.5 per ml. A recent performance test by D. H. Caldwell, formerly Assistant Engineer in this Bureau, following several years of use in which sludge had accumulated in nearly all the ponds, D.O. still ran high—12 to 20 p.p.m., B.O.D. from 5 to 25 p.p.m., and B. coli—2.3 to 23 per ml. These Calistoga ponds are really small. It is estimated that the sewage, which was quite weak, goes through them in only a few days' time. Recently, special tests were made of these ponds carried late into the night with tests resumed very early in the morning. These show the close relationship of lagoon action to actinic light. Before sunup, all the ponds were negative for D.O., but D.O. climbed rapidly after sunup. By 2:00 P.M., D.O. was at its peak. About sundown, the D.O. gradually fell off, but evidently there was enough in reserve from the daylight hours to carry a healthy condition through the night.

Skipping to the south end of the State, where light is strong, Imperial, in 1941, put in mechanical clarifiers and in lieu of a trickling filter, the city put in about 7 acres of rather shallow lagoons. These, too, were tested by the Bureau. D.O. ran as high as 25 to 35 p.p.m., whereas 6 or 8 p.p.m. would have been saturation.

Modesto is a case where lagoons are used as an adjunct to a badly overloaded biofilter and quite a heavy industrialized waste, to reduce the pollution load on Tuolumne River. Recently, Mr. Caldwell made a two-day performance test of these ponds under good conditions of control and opportunity for measurements. With plant efficiency only 37 per cent on a B.O.D. basis, approximately 1,500 lbs. per day oxygen demand was applied to a series of 7 lagoons having an area of about 9 acres and a depth of 1.5 feet. Without allowance for percolation, the nominal detention period in the ponds was 7 days. D.O. in the final ponds ran from 4 to 18 p.p.m., depending on the routing of the sewage to the various ponds, but it fell off to zero during the night the same as at Calistoga, and oxygen development resumed next morning. B.O.D. ran from 20 to 40 p.p.m. in the final effluent at midday, representing a B.O.D. transfer to the Tuolumne River of only 160 lbs., contrasted with 1,500 lbs. per day leaving the treatment works.

Even in fresh tidal rivers one may see true examples of lagoon action. In the dry year of 1931, upland flow ceased at Sacramento, but the river was tidal and the action distinctly that of a lagoon. Extensive studies by the Bureau were made of the river above and below Sacramento, and these showed that within a length of about 5 miles normal oxygen conditions in the river were restored. This experience indicated about 500 acres of river operating as a lagoon under the beneficial effects of tidal movement. D.O. returned to 7 to 11 p.p.m., and at no place was it below 6 p.p.m., in spite of the lack of upland flow. Stockton, likewise, really utilizes lagoon action in the San Joaquin River with similar pumping effect, according to tests by Wm. T. Ingram, while he was Sanitary Engineer of San Joaquin County.

I could go on with recitals like these in which more or less admittedly fragmentary tests confirm, in case after case, the purifying action of lagoons in California, so that there is no denying the phenomenon of oxidation and bactericidal action in them, and the potential usefulness of lagoon action, properly directed.

Discussion

By Willis T. Knowlton *

Some years ago the writer made a trip to many of the larger cities of the United States to study the methods they used for disposal of their sewage. One of these cities was Houston, Texas, where, at that time, the sludge from the activated sludge treatment tanks was disposed of by lagooning and which disposal did not create a nuisance. This method of disposal has at times been in the mind of the writer, as it was a simple and inexpensive one.

Evidently the use of lagoons for sewage disposal has also impressed Mr. C. G. Gillespie, Chief, Bureau of Sanitary Engineering, California State Department of Public Health, who wrote a paper last October on ''Ponding of Primary Plant Effluent'' for the Arizona Sewage and Water Works Association. In accord with a recommendation of Mr. Gillespie that lagooning, or the use of aeration ponds, could be added to the units for sewage treatment at an Army cantonment in Southern California, the writer, as designing sanitary engineer for this location, made a study of the value of such lagoons. As a result of the study, plans for the use of lagoons at this location were adopted.

That the aeration treatment obtained by the use of lagoons will give a natural purification to the polluted effluent from a sewage treatment plant is a statement that has been proven through investigations by the U. S. Public Health Service in intensive studies of the Potomac, Ohio and Illinois Rivers (see Public Health Report of U. S. Treasury Department, issued by the U. S. Public Health Service, July 16, 1937). These investigations, as described by W. C. Purdy, Special Expert of the U. S. Public Health Service, showed that cells of green algae of microscopic size, or larger, and sufficiently numerous to tint the water a scarcely perceptible green, will produce measurable amounts of dissolved oxygen under the average daily condition of sunlight. These amounts of plant oxygen will in three days cause an increase in the amount of dissolved oxygen in the pond or lagoon water as the algae increases, and will offset the loss of dissolved oxygen caused by the presence of organic matter.

Thus the dissolved oxygen content of the pond, or lagoon water, may average 100 per cent or more saturation on bright sunny days. It is possible that excessive depths of forty feet, or more, may not receive

* Consulting Sanitary Engineer, Los Angeles, Calif.

the increased amounts of dissolved oxygen that should take place in these ponds, or lagoons, where the depths do not exceed ten feet.

In addition to this oxidation of the bacteria in the ponds, it is possible that the dissolved oxygen produced by the algae will offset the putrefaction caused by any carry-over of suspended solids from the treatment plant. Such carry-over may contain 15 per cent, or more, of the total suspended solids in the sewage.

To provide for these ponds, or lagoons, at the Army cantonment above noted, the writer made surveys of ravines on the site proposed for sewage treatment. Dams to provide storage could be placed at intervals along the bottom of the ravines so as to hold for several days the effluent from the sewage treatment plant which he had designed. This plant included two 60-ft. clarification tanks, two 65-ft. biofilters, a 50-ft. digester, sludge beds and a chlorination detention tank, the effluent from which entered the ponds.

Studies of ponds, or lagoons, built elsewhere in California were made, and data were obtained from three places. The average area of these lagoons was 5.3 acres for an average population of 1,580.

For the Army cantonment above mentioned, the Bureau of Sanitary Engineering of the California State Department of Public Health recommended that there be allowed a maximum depth of three feet per acre and a B.O.D. content of 16 lbs. per acre-foot per day.

The writer considered that using such conditions it would be necessary to allow a minimum storage period of five days, or an average period of 6.7 days. Studies of two plans for this cantonment were made; one with shallow depths and the other with deeper depths. The latter was selected as it would give more capacity for the effluent to be treated.

For the complete layout there were eight different ponds, or lagoons, and the pipe system installed therefor allowed the alternate use of two or more of these different ponds at one time. Two ponds were to be filled at the beginning and then their content given at least five days storage before they would be emptied. In a similar way, three of the remaining ponds were then to be filled, stored for at least five days, and then emptied, after which the last three ponds would receive the effluent, and the treatment furnished by the other ponds. The rotation of this plan would then follow.

This plan of distribution permitted any of the ponds to be temporarily cut out of use, if desired, for cleaning, repair, or reconditioning. The plan above outlined would thus permit the effluent from the sewage treatment plant to receive an oxidation for a period of from five to seven days, and the final effluent from the pond treatment should be free from complaint, if discharged into a waterway.

Consideration was given to the matter of mosquitoes that might develop from the creation and use of aeration ponds. Adjacent to the edges of the ponds, the shallow water could provide a breeding place. However, for these shallow depths as well as throughout the entire ponds, the planting of mosquito fish, known as *Gambusia Holbrooki,* will provide means to destroy the mosquitoes. These fish are from 1 in. to 1-1/4 in. long, multiply rapidly and are not expensive.

A few remarks can be made on the excellent paper of Messrs. O'Connell and Gray:

(1) Due to immediate attention required to offset damage to existing plants in wartime, lagooning can be used.

(2) The trend of the past two decades has been away from simplicity in sewage treatment, and we should be more conservative and contribute to the soil fertility. Abel Wolman has emphasized this thought, and he, like William T. Sedgewick, has been a leader in sanitation.

(3) It is noted that the above mentioned paper states that the maximum loading should not exceed 2,000 to 5,000 gallons per acre per day on tight soils, or 4,000 to 15,000 gallons on sandy soils; that a minimum detention period of 20 days be used to eliminate bacteria, although five days was approved by the California State Board's engineers; that a minimum of 4 ft. depth is desired to avoid tules, rather than a maximum of 3 ft., as recommended by these engineers. The writer used five to seven days for the detention periods, and an average depth of 8 to 10 ft. for the ponds, but concurs with the plan that sewage treated therein should be at least settled before ponding.

EFFECT OF WAR ON CHEMICALS USED IN SEWAGE TREATMENT—A SYMPOSIUM *

WARTIME PRODUCTION OF ALUMINUM SULFATE

By Richard W. Ockershausen

Engineering Service Dept., General Chemical Company, New York City

Bauxite Situation

The story of wartime aluminum sulfate is one dealing with critical materials. Bauxite or aluminum ore plays the leading role because it is the essential raw material for the manufacture of aluminum metal and for aluminum sulfate.

In 1933 the consumption of bauxite in the United States was approximately 300,000 tons. By 1940, 1,068,000 tons were used and it is estimated in 1943 that 5,600,000 tons were used. Roughly 90 per cent of this went directly to plants producing aluminum metal for the tremendously expanded airplane program.

Sixty per cent of this material used in this country was imported prior to 1941 from British and Dutch Guiana. The reason for this was that the South American bauxite is one of the highest quality ores in the world and could be mined at lower cost than domestic ores. The low silica content was especially desirable, since this impurity is troublesome in both metal and chemical manufacture.

Submarine Warfare

You will recall the vicious submarine warfare in the Caribbean Sea in 1941. This warfare extended along the eastern coast of our country and took an unprecedented toll of shipping. Ore carrying boats were important targets to the Axis and the loss was great. The hazards of shipping through submarine infested waters caused our Government to restrict these imports to all except the most vital users.

Not only were boats being sunk by submarines but the necessity for all types of shipping craft for many war jobs became acute. We were fighting and aiding our Allies across thousands of miles of ocean and our Victory ships were just beginning to slide down the ways. Every boat was vitally needed and the shortage was very apparent.

Domestic Bauxite

This country has some deposits of good grade aluminum ore. These are chiefly in the southern states. The expansion in metal producing facilities was so great that enlarged stripping and mining operations were necessary here. Still, the ore from the vastly increased domestic

* Presented at the 29th Annual Meeting, New Jersey Sewage Works Association, Trenton, N. J., March 23–24, 1944.

production, plus the imported ore, was barely able to meet the requirements of the enormous airplane program. It was found that bauxite containing high silica could not be processed satisfactorily in many of the metal plants, further complicating the supply problem.

In the early days of the war when the strength of the Axis seemed overwhelming, Canada, to insure having sufficient aircraft production, expanded its aluminum producing facilities to a reported billion pounds of the metal annually. When direct importation of bauxite from the Guianas became so hazardous it was necessary to keep these plants operating by shipping ore from the United States by rail. This placed a further strain on production of domestic high-grade bauxite.

War Production Board Action

For the reasons given above the W.P.B. was faced with doling out the none-too-plentiful supply of bauxite to essential users. Aluminum production naturally came first. The manufacture of chemicals for public health purposes was of next importance. The processes used for metal production could not satisfactorily use ores of high silica and high iron content. The W.P.B. approached the executives of the American Water Works Association and leading sanitary engineers throughout the country for their views on the requirements as to the quantity and quality of aluminum sulfate that could be used by water and sewage treatment plants.

It appeared early that users of bauxite other than metal plants would have to take lower grade domestic ores. The W.P.B., realizing the problem of converting chemical plants to low grade raw materials, consulted with the chemical manufacturers to determine the type of product that could be made, and to see if it would meet the requirements most sanitary engineers agreed could be used. As a result, the W.P.B. restricted the use of high grade bauxite after September 1, 1942, permitting only aluminum production from this material. The manufacture of chemicals had to be from ores containing over 15 per cent silica.

All of the manufacturers of aluminum sulfate using bauxite as their raw material were similarly affected. The following shows the general differences in the bauxites available before and after September 1, 1942:

	High Grade Bauxite	Emergency Bauxite
Al_2O_3	55 to 70%	45 to 58%
SiO_2	1 to 3%	15 to 25%
Fe_2O_3	0.5 to 2.5%	1 to 9%
H_2O	10 to 30%	10 to 30%

Silica, Insoluble Material and Iron Content

As mentioned before, silica is the most troublesome ingredient in bauxite. Silica is largely in the form of aluminum silicate in the ore. It is not readily attacked by sulfuric acid, used in digesting the ore. The problem was how to get rid of silica and yet retain the valuable alumina tied up with it. It was recognized that manufacturers could not remove silica entirely from the finished product with existing manufacturing equipment and this presented another problem. It was impossible to obtain additional equipment at this time because the synthetic rubber and aviation gasoline programs had first priority on critical materials and equipment. It was evident that as long as a usable aluminum sulfate could be made, that was as far as the manufacturers could go. Research and ingenuity were the only hope if a better aluminum sulfate was to be produced.

Inability to remove silica was expected to result in a certain dilution of the product or lowering of the aluminum oxide (Al_2O_3) content, and a rise in the insoluble materials. It will be noted from the analyses of the bauxites given that the 1 to 3 per cent silica ores were no longer available, and raw material containing 15 per cent silica and higher had to be used. It was expected with this raw material the Al_2O_3 might drop from 17 per cent to 14 per cent and the insoluble material might run as high as 15 per cent.

Specification Changes

The executives of the American Water Works Association and the officers of the Water Purification Division reviewed the specifications that water and sewage treatment plants use in purchasing their aluminum sulfate. It was obvious that the manufacturers were placed in a position where these specifications could not be met. Emergency Alternate Specifications were adopted on June 25, 1942. The former and present specifications, with respect to chemical analysis, are as follows:

	Former Specifications (Per Cent)	Present Specifications (Per Cent)
Water Soluble Al_2O_3	17 (Min.)	14 (Min.)
Iron as Fe_2O_3	0.75 (Max.)	3 (Max.)
Insoluble	0.50 (Max.)	15 (Max.)
(Unpurified)	7.50 (Max.)	

The manufacturers kept faith with the consumers by not seizing the new specifications as justification for producing a low quality product if it were possible to make a better one. Research chemists vigorously attacked the manufacturing problems. New methods were developed which enabled the production of a very good grade of aluminum sulfate, one which was far better than had been anticipated. It is not believed the strength of any aluminum sulfate on the market fell to the 14 per cent Al_2O_3 specification. At a symposium on Victory alum held in Harrisburg, Pa., in June, 1943, it was stated by a speaker that an average analysis of 10 samples from different manufacturers showed 15.6 per cent Al_2O_3, 0.34 per cent Fe_2O_3 and 6.08 per cent insoluble material. Since the first change in the product, there have been many improvements in quality and major producers are still devoting much time to this end.

Effect on Coagulation

With respect to coagulation, the present aluminum sulfate compares well with the former product. Six plant operators at the Harrisburg meeting previously mentioned told of their experiences with the new material. Five reported using no more aluminum sulfate and three of these reported savings in dose or improved floc formation. The sixth reserved opinion until he had further experience. Most of these operators attributed their success with the new product to the coagulating effect of the aluminum silicate or insoluble material, which fact has been long recognized by some of the large water plants in the country. The insoluble particle provides a nucleus for the aluminum hydroxide floc to build upon, and often a heavier floc results.

Special attention has been given the particle size of the insoluble material to reduce the feed-line clogging problem, and to insure the material carrying over to the settling basins or clarifiers. Some difficulty was experienced at first but this has been largely overcome. Plants using solution tanks find that agitation keeps the fine soluble material in suspension. Some of the dry-feed machine manufacturers have studied the feeding problem and are making improvements to give more agitation and better solution of the material in the solution pots of the feeders.

Conclusions

The sewage plant operators deserve a great deal of credit for the clever ways in which they have solved problems in using the wartime alum. Many gadgets have been developed for flushing and cleaning feed lines, for increasing the velocity in these lines and for improving agitation in the solution of dry-feed machines. Some operators have been more watchful of their aluminum sulfate doses and this resulted in better operation in these plants.

The manufacturers accepted the challenge of making good quality aluminum sulfate from low grade bauxite and have succeeded to a marked degree. If the quality of the present bauxite does not change radically for the worse, you should see no lowering in the quality of the present product. Actually, the quality picture is viewed with optimism, improvements are being made daily, and the sewage plant operators are benefiting from our constant study of this problem just as quickly as research can be interpreted into practical operation.

WARTIME PRODUCTION OF CHLORINE

By Ralph L. Carr

Technical Division, Mathieson Alkali Works, Inc.

Even before the United States became an active participant in this war, it became evident to the chlorine manufacturers that there would be an increasing demand for chlorine. Therefore, they were not entirely unprepared for the large demands that have been made upon them for this most essential chemical. This was fortunate because it can be said in all truthfulness that no other chemical is so necessary to the average sewage plant as is chlorine. No matter what happens in the sewage plant, if enough chlorine is added to the effluent, it may be discharged to streams without fear of undue contamination. No other chemical will serve this purpose.

Due to its nature, chlorine cannot be adulterated and it is in the same state of purity today as it was before the war started. (I use the world adulterated advisedly for no matter how other chemicals have had to be modified it was due to necessity and not to the desire of the manufacturer.)

Despite the precautions taken by the manufacturers, they have been hard put at times to keep all their customers supplied with chlorine. In order to conserve this essential product, the War Production Board ruled that certain industries must reduce their consumption of chlorine. As one example, paper mills formerly used very large quantities of chlorine to bleach raw paper stock. Since the war they have been limited as to the whiteness of the paper they can produce and, consequently, use considerably less chlorine. However, it was obvious that sewage plants could not reduce the amount of chlorine they used and still safeguard the health of their communities. The Government realized this and wisely allowed them their full requirements.

Since so many water works and sewage plants take their chlorine in cylinders, it soon became apparent that these containers were very important. The large demand for steel in the war effort made it obvious that fewer new cylinders could be obtained by the chlorine manufacturers. Of course, limited quantities were available and these were quickly pressed into service. By letters, and by advertisements and by editorial co-operation on the part of leading trade papers, the chlorine suppliers requested a quick turnover of chlorine cylinders. It is a signal contribution of all of you to the war effort that by your fine cooperation the average reuse per year of each cylinder was increased in the last two years. This is real progress but a greater effort on your part is urged. All chlorine manufacturers need to have their empty cylinders returned as quickly as possible. All of you may help in this.

Most truckers may not want to pick up one or two cylinders, but please keep after them so that the empties may be returned as promptly as possible to the manufacturers. Sometimes your own trucks could carry the empties to the freight station without undue trouble. You could even place them in the back of your own car and take them to the station. It all may sound small and picayune because it involves just one or two cylinders, but if all users did that, it certainly would help the chlorine suppliers.

In order for you to understand some of the trouble the chlorine suppliers have had during the past two years, I would like to cite a few examples. Sometime ago we received a telephone call from an Army camp. The officer said that they had to have twenty-five cylinders of chlorine in a matter of a few hours. Shipping from our plant was impossible; the chlorine was needed at once. We suggested that the officer send an Army truck to one of our warehouses and pick up the twenty-five cylinders. He agreed to do this and thanked us for our co-operation. Naturally, we were very pleased that we could be of service and were congratulating ourselves on a well done job. Imagine our surprise and dismay when our warehouse man called and told us that the Army had taken all of the chlorine we had stocked, some seventy-five cylinders. Of course, the Army should take all necessary precautions to protect their men but by this act they had jeopardized the safe and efficient operation of the water and sewage plants of the communities for which this stock had been established. Taking 75 cylinders when 25 would have been sufficient served no useful purpose and caused us a lot of trouble and worry.

Another Army camp called us when their sewage plant was ready to begin operation. They asked us how much chlorine they should order. From the data they gave, we suggested that they order 75 cylinders and repeat the order at definite intervals. The officer agreed to do this. When we received the order it was for three hundred cylinders. Since they had the authority to obtain this amount there was nothing we could do but to ship the entire quantity demanded in the order. They did not need all that chlorine and it seriously reduced our cylinder stock. Your guess is as good as ours as to how many of those cylinders will ever get back to our plant.

When we first started shipping cylinders to the Army, we waived the usual cylinder deposit. Later, after losing so many of them, we insisted on a deposit. Now, due to the change of personnel, some Army camps believe that they have made a deposit on all the cylinders they ever received. When we try to recover the cylinders which were shipped without a deposit, the purchasing officer wants his deposit on the barrel head or no cylinder. After writing innumerable letters and getting into more and more Army red tape, the management usually just gives up and we are out several cylinders.

Fortunately for all of us the War Production Board recognized the difficulty of supplying all of the Army and Navy camps with cylinder chlorine and authorized the purchase of several thousand cylinders. This has been of immense help to the manufacturer but has not entirely relieved the situation. When you realize that the chlorine suppliers have lost between 20 and 25 per cent of their cylinders you begin to understand the importance of promptly returning all empties. What would any of you do if you lost 25 per cent of your sludge digesting, drying or removal equipment?

I don't want you to get the idea that this is a diatribe against the Army. It isn't. There are still quite a number of civilian users of chlorine who have absolutely no respect or regard for chlorine cylinders. The Army is confronted with an enormous job and is doing it wonderfully well. We are losing chlorine cylinders and will probably continue to lose them. It behooves us, therefore, to do all in our power to keep the equipment we have rolling and thus to aid a little more in the all-out war effort.

WARTIME PRODUCTION OF FERRISUL

By Francis K. Burr

Technical Service Dept., Monsanto Chemical Co.

The problems we have faced in supplying chemicals to the sewage treatment field are similar to those experienced in other lines of material. There have been wide variations in the demand for coagulants, brought about mainly by their use in other fields of endeavor. The present discussion will be limited to the situation involving Ferrisul—anhydrous ferric sulfate. Fortunately, or unfortunately, depending on the point of view, Ferrisul has many applications in varied fields. Besides sewage coagulation and water coagulation, it is used as a pickling agent to remove scale after annealing. Some of you who have used it in your plants have noted its ability to dissolve other than special alloys. In agriculture it is used as a weed control material. It finds limited use for pigment manufacture as well as other specific industrial uses which will be referred to later.

At Pearl Harbor time, two-thirds of our productive capacity went into the allied fields of sewage, water and boiler water treatment. The remainder went primarily to the metal treatment field. We were completely sold out and were contemplating an expansion of our facilities when the advent of war made this impossible.

Wartime Developments

Things began to happen so rapidly that it became a problem to keep step with changing conditions. Figuratively speaking, plants accustomed to the manufacture of plowshares were making the swords of war. The manufacture of brass and steel cartridge cases greatly increased the demand for Ferrisul as did other processes in the metal industries. A use for Ferrisul was found in the rubber program. Information concerning this has been withheld, but the usage was not for water or waste treatment.

These developments occurred at a time when water and sewage treatment plants were able to offer priorities of A-2. The uses above offered A-1-A priorities. We had no choice in the matter but to serve these customers whom agencies of the government declared more essential.

The heavy demand by these war industries soon made it necessary to turn away customers of long standing in the field which ultimately offered the greatest opportunities for Ferrisul—your own and the water treatment field. You can imagine that such a course was not pleasant.

Finally, as you realize, the realm of public health came into its own and was granted AA-2X, then AA-1 priorities. This put our field on a par with the industries in the matter of securing certain materials. You can imagine the mad scramble that might have occurred with all users offering equal priorities to a tonnage figure far in excess of our ability to produce.

Well, it never got to that point, we are happy to say. I say we are happy because we have seen enough of being oversold. As frequently happens in government purchasing, the rate of consumption of Ferrisul was greatly overestimated. This was particularly true in the rubber program. There Ferrisul was going further than was indicated by small-scale experiments. Also the steel cartridge case program folded. We were not only spared the grief of being oversold, but found ourselves with a modest surplus.

Chemical Feed Equipment

Early in the war another problem confronted us. Those of you who are familiar with the dissolving characteristics of Ferrisul recall that a dissolving pot with a mechanical agitator is required. The most satisfactory metal for this agitator is Allegheny metal or 18–8 stainless steel. In spite of its toughness the propeller blades wear out and must be replaced. The wearing is due to erosion and not corrosion as the solution of Ferrisul acts to passivate stainless steel.

This metal was pretty much beyond the reach of the sewage treatment group because of the demand by war industries. It carried a priority much higher than could be offered by our group. Because there was a hundred or so water and sewage treatment plants that would probably require some replacement before the end of the war, and because a hundred small applications to the War Production Board would get less response and cause confusion, our company filed a special request in the name of these users for sufficient shaft and propeller material. The stainless steel is kept in a special inventory and allotted as needed to water and sewage treatment plants throughout the country. The total amount was about 200 lbs.

Most of this stock is gone, but we feel it will still see us through. In the meantime, the AA-1 priority which you now have is sufficient to secure this material so our task is pretty well over for the moment at least.

Conclusion

We have been fortunate in not having to change our specifications as was necessary in our manufacture of alum. On the other hand the trends noted above have kept us more than occupied.

WARTIME PRODUCTION OF HYDRATED LIME

By Harry C. Bixler

Asst. to President, Limestone Products Corp. of America

We are distinctly honored to have the privilege of presenting this paper before your meeting and sincerely trust our effort will not only point out the effects of the war on the production of hydrated lime, but will also give you an insight into the operation of our calcium hydroxide division—producing a high quality hydrated lime for water and sewage treatment plants.

Our stone deposit is known as Franklin limestone and has a distinct crystalline structure. The calcite crystals are rhombohedral, are relatively coarse and generally the crystals range in size from 1/8-inch to 2-inch cubes. The calcite deposit is unusual and is the only one of its kind in the eastern section of the United States. It is interesting to note that the calcite retains its crystalline form throughout the manufacturing process even though the finished product may contain a high percentage of sizes as small as one micron.

A brief resumé of the manufacturing process will indicate the highly specialized nature of the operation and this is necessary to understand the effect of the war on this particular plants' operations and its products.

Hydraulic stripping methods are employed to remove an average of approximately 10 inches of earth covering the stone—water under a pressure of 100 lbs. per square inch at 300 gallons per minute is used for this purpose and is controlled by a patented nozzle. The various quarry faces are well drilled and the stone sampled for every 10 feet of drilling. These samples are analyzed in the laboratory to determine the quality of this stone. After the entire length of a quarry face (140 to 500 feet) has been drilled it is ready to be blasted. The holes are 6 inches in diameter by 40 to 95 feet deep and there may be 7 to 25 holes on any one face. The holes are then loaded with a combination of 60 per cent and 70 per cent dynamite and all shot together—the tonnage blasted usually varies from 10,000 to 50,000 tons and from 3 to 15 tons of dynamite is used in each shot.

The larger size stone is drilled with air operated drills known as jackhammers and blasted, then loaded by electric shovels onto quarry service type trucks and transported to the crushing division. The primary crusher crushes the stone at a rate of 200 tons per hour producing a maximum size stone of 5 inches. This product is then directed over picking belts (where objectionable stone is manually rejected) and then to secondary crushers, which operate in a closed circuit with vibrating screens. Here, the size of the stone used in the calcining division is carefully controlled and held to close tolerances. These finished sizes are conveyed several hundred feet, directed over a final vibrating screen cleaning operation, sampled every 30 minutes and stored in several concrete silos. The stone, as sampled at this point, is analyzed in the laboratory for control purposes and at this stage of the process is ready for calcining.

You probably have noted the care used to check the quality of the stone as it is drilled and sized for calcining. The chemical analysis of the stone at all stages of the operation is definitely known, and only the highest calcium carbonate stone in the deposit is used for the manufacture of chemical hydrated lime.

Rotary kilns are used for converting the carbonate stone to oxides—known as calcining or burning. These kilns operate continuously 24 hours per day, 7 days per week. They are lined with 6 inches of firebrick and are fired with pulverized coal. Generally this calcining operation lasts 2-1/2 hours and the temperature in the calcining zone of the kiln is approximately 2,300° F. The finished product at this point—known in the industry as burned lime or oxides—is sampled every 15 minutes by the operators who examine it visually and test the sample with technical hydrochloric acid to determine the CO_2 remaining in the burned lime. An experienced operator is able to judge very accurately the percentage of CO_2 remaining and maintains a CO_2 content of approximately 1 per cent (a tolerance of 1/2 per cent above or below 1 per cent is considered satisfactory). The samples taken are grouped for each shift, sent to the laboratory for complete chemical analysis and the CO_2 results are reported daily to the operators for their information and guidance. This system makes possible the production of a uniformly burned product.

After burning, the oxides are directed through rotary coolers and stored in steel tanks for a short period of time prior to hydration.

The hydrate plant is unquestionably as modern and complete as any in the United States and makes use of many specially developed machines not found in any other hydrate plant. This plant was completely rebuilt just prior to Pearl Harbor, and is made up of a patented process plus many unique machines, utilized so as to maintain a uniformly high quality product with the highest degree of efficiency. Ordinarily, one machine is used to mix water and the oxides to produce a crude hydrated lime, however, in this plant the work is more thoroughly accomplished by using three different type machines, any one of which is generally used singly by most producers to accomplish the job. This method, combined with many other control features, makes it impossible to produce anything but a high quality, completely hydrated lime. The fineness of the finished product is uniformly maintained by directing the crude hydrate through a series of large air separators. During this part of the operation, a specially designed machine centrifuges the material and automatically rejects from the system all objectionable material such as silica, iron, alumina, overburned and underburned particles. The fineness is all controlled with the air separators mentioned in the foregoing—there is no ball mill grinding of any kind in the system. We depend on proper burning, hydration and air separation methods to obtain the desirable quality and fineness of the finished product. This chemical hydrated lime as furnished sewage treatment plants has an average particle size of 2 microns. The finished product is conveyed to the packing department where it is properly sampled, packed in multi-wall valved bags, loaded on cars and trucks or stored in a 320-ft. long warehouse. The samples are forwarded to the laboratory for complete chemical and physical analysis, including plasticity tests.

Power for this entire process as briefly described in the foregoing, as well as the power needed for our many other products not discussed in this paper, is generated by full Diesel engines direct connected to generators. This power plant is reported to be the largest commercial plant in the State of New Jersey, has a generating capacity of 2,120 horsepower and is composed of 4 engines, any of which can operate singly or in combination with any of the other engines.

Fortunately, the war cannot alter the quality of the natural resource (calcite) used to manufacture the hydrated lime described in the foregoing. We are affected, however, from every other conceivable angle, the same, more or less, as every other industry and have our many troubles obtaining necessary priorities to purchase needed material and equipment. A monetary value cannot be placed on the co-operative effort employed in our behalf continuously by all suppliers of materials, equipment and services. These industries, through their service representatives and engineers, have many times, by their helpful action and advice, given our morale and the "will to keep fighting" and producing, an indispensable boost. In order to produce a ton of hydrated lime, a lot more is needed than just raw material and labor. It is necessary to have available approximately 3,000 different maintenance and operating supply items for our particular operation—many of them on the critical list and very difficult to obtain. In our purchasing department, during the years prior to Pearl Harbor, we developed a lenient, fair, non-chiseling practice which has developed a wealth of good will and, during this emergency, has proved to be invaluable. We thoroughly appreciate that these many good friends—all suppliers of equipment and materials—are giving us the best service and materials obtainable during these strenuous times. True, we are asked to and do use substitutes many times—occasionally we have found a substitute better than the prewar article.

The general manpower shortage, affecting all industry, is our major problem. That just does not appear to have a solution; all other troubles seem insignificant by comparison. From the foregoing description of the process, it will be apparent that this is a highly specialized process, requiring a considerable number of trained men. We have always had a training program, when men were available, however, 34 per cent of our personnel are now serving in the armed forces and many of those in training prior to Pearl Harbor have enlisted or have been taken by Selective Service. In order to furnish men to our armed forces and still continue operation, we have co-operated with the War Manpower Commission and Selective Service wholeheartedly. You may be interested to note that our company was the 94th in the State of New Jersey to have manning tables and a replacement schedule accepted by Selective Service headquarters in Trenton. Our third six-months renewal replacement schedule has recently been approved. We have investigated the possibility and advisability of using war prisoners, but found this was not practicable for our particular requirements. We also investigated using Jamaicans, but these people are prohibited by an Act of Congress from working anywhere except on agricultural farm projects. The United States Employment Service Offices have done their best to furnish men, but have none to offer in our particular section due to the heavy demands of direct war industries, such as Picatinny Arsenal, Hercules Powder Company, Wright Aeronautical, etc. The net result of our inability to maintain a full working force has reduced our capacity of hydrated lime 40 per cent and we do not visualize any possibility of improvement for the duration. The quality of the product has been improved due to several changes in the process recently, but the production does not begin to equal the demand for this essential product.

There are many industries using hydrated lime, all of which are highly important, and it is not possible to furnish all of them with their entire requirements for the duration. We must favor those industries whose service is considered to be of the greatest importance to the welfare of the nation and accordingly have given water and sewage treatment plants priority on our production of hydrated lime. We have every reason to believe that (barring any unforeseen change in Selective Service regulations) we shall be able to supply water and sewage treatment plants with the same quality product in the same quantities as required by these plants in the past.

Sewage Research

SURVEY OF RESEARCH PROJECTS UNDER INVESTIGATION AND REQUIRING STUDY—1944

Committee on Research, Section B

Federation of Sewage Works Associations

By Willem Rudolfs, *Chairman,* A. E. Berry, F. J. Brinley, E. F. Eldridge, H. Ell, V. P. Enloe, A. L. Genter, D. D. Heffelfinger, W. Q. Kehr, K. C. Lauster, G. Martin, G. Marx, E. R. Mathews, R. S. Phillips, R. Pomeroy, M. E. Rogers, J. H. Ruge, Geo. E. Symons, F. S. Taylor, S. R. Weibel, W. S. Wise, C. H. Young

The compilation of titles of research projects under study and problems requiring investigation has been continued this year. The lists of titles, brief descriptions of the purpose of the work, and the names of the investigators follow the scheme established previously.

Practically all associations are represented on the committee. The associations represented are as follows:

Association	Representative
Arizona Water and Sew. Wks. Assoc.	G. Marx
California Sew. Wks. Assoc.	R. Pomeroy
Central States Sew. Wks. Assoc.	G. Martin
Dakota Water and Sew. Wks. Conf.	K. C. Lauster, G. J. Hopkins
Federal Sew. Wks. Assoc.	S. R. Weibel
Florida Sew. Wks. Assoc.	J. H. Ruge
Georgia Sew. Wks. Assoc.	V. P. Enloe
Kansas Water and Sew. Wks. Assoc.	M. E. Rogers
Maryland-Delaware Water and Sew. Assoc.	A. L. Genter
Michigan Sew. Wks. Assoc.	E. F. Eldridge
Missouri Water and Sew. Conf.	W. Q. Kehr
New England Sew. Wks. Assoc.	W. S. Wise
New Jersey Sew. Wks. Assoc.	H. Ell
New York State Sew. Wks. Assoc.	Geo. E. Symons
North Carolina Sew. Wks. Assoc.	R. S. Phillips
Ohio Sew. Wks. Conf.	D. D. Heffelfinger
Oklahoma Water and Sew. Conf.	F. S. Taylor
Pennsylvania Sew. Wks. Assoc.	C. H. Young
Sew. Division—Texas Section S.W.W.A.	F. J. Brinley
The Canadian Inst. Sew. and Sant.	A. E. Berry

All members made a more or less thorough search in their territories to obtain information which could be compiled in a report. Some of last year's members are now with the armed forces and their places have been taken by other representatives.

The first attempt to collect a list of research projects was successful. The lists presented are supplementary to those published last year in the May and July *Journals.* Since a considerable number of projects run longer than one year, no attempt has been made to relist or restate the previously listed projects, neither has an attempt been made this year to indicate the projects which have been completed. For this reason the numbering of the projects has been continued, with the object in mind of indicating in a later report those projects still under study and those which have been completed.

I. Problems Under Investigation

The number of problems under investigation this year is 94 as compared with 128 last year. The titles given in Table 1 allow some interesting comparisons with those published in the May and July issues of 1943:

	1943	1944
Sewage	70	35
Industrial waste	41	49
Stream pollution	11	5
Methods	6	5

This year the emphasis on industrial waste is still more pronounced in actual number of projects and has increased from 32 per cent of the total number of projects to 52 per cent of the total number of projects under study. The importance of industrial waste treatment in the coming years appears to be foreshadowed by the number of projects. There is little doubt that industrial waste treatment and all its problems will be increasingly in the limelight and will require more and more specialized knowledge.

A breakdown of the problems under study pertaining to sewage treatment is of interest. The three major phases, namely: sludge treatment and disposal of sludge, various forms of filtration and activated sludge, are this year rather evenly divided. A comparison with last year shows a material reduction in the number of problems pertaining to sludge treatment.

	1943		1944	
	No.	Per Cent of Total	No.	Per Cent of Total
Sludge	33	47	10	28
Filtration	5	7	8	23
Activated sludge	7	10	9	27

The 49 projects pertaining to industrial waste are grouped together to determine whether particular types of waste receive more attention.

A comparison with last years list shows:

	1943	1944
Sugars and fermentation	5	2
Paper wastes	7	6
Textile and dyes	6	7
Pickling liquors	6	5
Acid wastes	4	4
Laundry wastes	4	1
Oil wastes	1	5
Rubber wastes	0	6
Food, canning, tannery	4	10

The problems pertaining to the new artificial rubber industry, although localized, appear to require considerable study. This is followed by the new dehydrated food industries. With the exception of oil wastes, all other industrial wastes are receiving as much study, as far as number of projects is concerned, as last year.

The number of projects pertaining to stream pollution are less this year, whereas the numbers of projects dealing with analytical methods are nearly the same:

	1943	1944
Stream pollution	11	5
Methods	6	5

The nature of these projects and the agencies capable of investigating these types of problems are such that no material expansion or changes could be expected.

II. Problems Requiring Investigation

The problems submitted indicating required investigations have been divided under the same sub-headings as those under study. In total, 41 problems were suggested as compared with 31 last year. Grouping the suggested problems and comparing them with those suggested last year we find:

	1943	1944
Sewage	14	15
Industrial wastes	12	17
Stream pollution	3	0
Analytical methods	2	9

The emphasis on industrial waste treatment processes requiring study indicates the trend. The sewage treatment problems suggested cover a rather wide field. Among the industrial waste problems suggested, the wastes produced by food industries come first, followed by textile and paper wastes. No stream pollution investigations were suggested. Of particular interest are the suggestions dealing with analytical methods. Most of the suggestions seem to indicate the need for development of simpler tests, rather than the improvement or refinement of existing laboratory methods. It appears that simple plant control tests are required for the small plant operators. One of the committee members, who in the course of duty visits many of the smaller plants, writes: ''With respect to tests for the sewage plant operator, stress should be laid on the usefulness of a test for plant control. A test which requires several days for its evaluation has little or no value to the man who needs the results immediately. The trend in recent years has been towards refinement and perfection of methods in order to yield better comparable results for all investigators and better correlation of results from different laboratories. The needs of the man who has to produce results, for simpler and quicker determinations have, however, been neglected to a point where even the better operator began to lose interest and abandon the performance of routine tests. In many instances, visual observations and rules of thumb are employed by the operators and the laboratory equipment becomes settling space for atmospheric dust that must be periodically cleaned but is not used. My appeal is not for the glamorization or popularization of routine sewage tests. I believe that inventive genius is not lacking in the sewage works profession to devise sound, simple, and rapid methods that will answer the needs of operators.''

In the sewage works field there are two general requirements for analytical methods: (1) for research and (2) for plant operation. In many instances the methods used for research, particularly those pertaining to the determination and removal of suspended solids, are fairly sound, simple, and rapid. Most of these methods can and are used by operators interested in the performance of their plants. Methods of determining the performance of digestion units are at hand and are rather simple. When difficulties occur in the digestion processes, several methods are available to give an insight into the troubles. These require more work and are in many instances performed as routine tests. This does not mean that methods pertaining to solids determinations and those used in digestion control cannot be improved or that no search for new and simpler methods should be made. When it comes to determining chemically or physically the action of organisms in oxidation devices (filters and activated sludge), the methods devised to date require time, because use is made of living organisms or the chemical reactions are slow and time is required to come to equilibrium. It is possible that improvement of methods for research and performance tests may go hand in hand. Suggestions as to the nature and type of the tests and the functions they should serve may possibly be made by those most interested, namely, representatives of state health departments and operators, and could be listed as a guide.

In a previous report attention was called to the fact that few of the suggested problems dealing with industrial wastes treatment emphasized the necessity of by-products recovery. It would seem that proper treatment to prevent pollution is of more importance at present than finding ways and means to compensate industry for their share in pollution abatement. This may be considered as a healthy sign as far as the general problem of stream pollution and the effect of industrial waste on sewage treatment processes is concerned. It is likely that anyone

TABLE I.—*Survey of Sewage Research Problems*

No.	Title of Project	Description	Investigator, Organization
129	Odor Removal	Use of spray scrubber for removal of odors from air.	Gail P. Edwards, Dept. of Public Works, New York City.
130	Cathodic Protection of Metal Screens	Corrosion prevention of metallic screens on sewage filter is studied by modified cathodic method used for water storage tanks.	A. Kozma, Rutherford Joint Meeting, East Rutherford, New Jersey.
131	Flotation of Sewage	Vacuum flotation of sewage to increase removal of grease and suspended material.	A. J. Fischer, The Dorr Co., New York City.
132	Sewage Treatment	Treatment of stale sewage wastes mixed with packing house wastes where the sewers are flat and the sewage is warm the year around, i.e. southern conditions in flat countries.	University of Florida, Ocala, Florida.
133	Septic Tanks	Comparison of usefulness of various detention periods.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.; Mass. St. College; Mass. Agr. Exp. Station.
134	Disposal of Septic Tank Effluents by Sub-Surface Leaching	Determination of saturation point of fine soils.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.; Mass. St. College; Mass. Agr. Exp. Station.
135	Sludge Digestion	Comparison of mesophilic and thermophilic digestion and combination of the two types.	A. J. Fischer, The Dorr Co., New York City.
136	Controlled Digestion	Control of scum formation in sludge digestion tanks by ammonia nitrogen.	H. E. Schlenz, Research Dept., Pacific Flush Tank Co., Chicago, Illinois.
137	Digestion of Ground Garbage with Sewage Solids	Determination by plant scale operation, the most feasible method of adding garbage to sludge digesters.	David Backmeyer, Supt. Sewage Treatment Plant, Marion, Ind.
138	Sludge Digestion	Preliminary study of Metropolitan (Boston) sludge, for proposed disposal works.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.
139	Sludge Digestion	Effect of toxic industrial wastes on sludge digestion. Laboratory and plant experiments.	Louis Fontenelli, Rahway Joint Meeting Treatment Plant, Rahway, New Jersey.
140	Study of Digestion of Simple Chemical Substances	Some organic salts during digestion fail to give the theoretical increase in alkalinity.	P. D. McNamee and J. E. Rice, District of Columbia Treatment Plant, Blue Plains, D. C.
141	Study of the Presence of a Volatile Iron Compound During Sludge Digestion	Discovery of such a compound in the vacuum distillate of digesting sludge suggests the evolution of iron carbonyl during digestion.	P. D. McNamee, District of Columbia Treatment Plant, Blue Plains, D. C.
142	Use of Florida Sands	Study of natural Florida sands for use in sewage and industrial waste treatment. Study is divided into three parts: (1) collection and classification of sands, (2) determination of biochemical properties of sands, (3) pilot plant experimentation.	George W. Reid, Eng. and Ind. Exp. Sta., Univ. of Florida, Gainsville, Florida.

TABLE I.—*Continued*

No.	Title of Project	Description	Investigator, Organization
143	Intermittent Sand Filters	The more efficient use of intermittent sand filters by using improved methods of distribution such as rotary distributors.	J. Donald Walker, Amer. Well Wks., Aurora, Ill.
144	Oxidation of Reduced Sulfur Compounds	The rate of oxidation and the effect of reduced sulfur compounds on sewage treatment processes.	N. J. Agr. Exp. Sta., Dept. of Water & Sewage Research, New Brunswick, N. J.
145	Study of Forced Aeration for Standard Trickling Filters	Determination of forced draft aeration on the efficiency of standard trickling filters receiving chemically pretreated sewage. Ventilation by wind operated monitor type installed on stacks located along circumference of circular filters.	A. Kozma, Rutherford Joint Meeting, East Rutherford, N. J.
146	Biological Filtration	Studies on high-rate filtration of sewage to increase efficiency and degree of purification.	A. J. Fischer, The Dorr Co., New York City.
147	High-rate Trickling Filters	Determination of maximum possible B.O.D. loading; ratio of loading of B.O.D. to removal; comparison of recirculation with further treatment on secondary filter.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.
148	High-rate Secondary Sand Filtration of Trickling Filter Effluents	Sand filtration of trickling filter effluents at high rates to find saturation points with (*a*) continuous rate and (*b*) periodic increases and decreases in rates.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.
149	Oxidation of Chemically-Treated Effluent Containing Sugars	Pilot plant studies on effluent to remove soluble B.O.D.	B. C. McMenamin, Middlesex Sewage Treatment Plant, Middlesex, N. J.
150	Basic Research on Activated Sludge	Determining activity of activated sludge	Amer. Well Wks., Aurora, Ill.
151	Modified Sewage Aeration	Short-period aeration of sewage with low return solids.	L. R. Setter, New York City.
152	Activated Sludge	Use of $CaCO_3$ powder as a settling aid for activated sludge.	R. Eliassen and H. B. Schulhoff, New Jersey.
153	The Control of the Sludge Index	A plant scale study of a process wherein the sludge index of activated sludge is kept relatively constant.	L. S. Kraus, Peoria Sanitary District, Peoria, Ill.
154	High-Rate Operation of Activated Sludge	Development through recirculation of high-rate operation of the activated sludge process and analogous to that of high-rate filter operation. Plant-scale basis at Columbia, Mo.	J. A. Logan, Russell and Axon, Cons. Eng., St. Louis, Mo. and Infilca Co.
155	Vertical Aeration Plate Holder Studies	Study of aerating efficiency, air distribution and clogging.	L. E. Langdon, Research Dept., Pacific Flush Tank Co., Chicago, Ill.
156	Diffuser Plate Cleaning	A study of methods and efficiency of diffuser plate cleaning in place.	Gail P. Edwards and L. R. Setter, New York City.
157	Treatment Organisms	Comparative studies of the flora and fauna of various methods of sewage treatment to determine if certain methods have characteristic types, with a possible evaluation of the functions of these types.	J. B. Lackey, U.S.P.H.S. Water and Sanitation Investigations Station, Cincinnati, Ohio.

TABLE I.—*Continued*

No.	Title of Project	Description	Investigator, Organization
158	Pure Cultures	The functions of pure (bacteria free) cultures of protozoa and algae in sewage treatment and reaeration of water.	J. B. Lackey, U.S.P.H.S. Water and Sanitation Investigations Station, Cincinnati, Ohio.
159	Contact Aeration	A study of some features of contact aeration.	J. B. Lackey, U.S.P.H.S. Water and Sanitation Investigations Station, Cincinnati, Ohio.
160	Fertilizer Value of Sludge	Determination of the agricultural value of digested activated sludge.	H. W. Charlton, New York City.
161	Destruction of Pathogenic Organisms in Sludge Used as Fertilizer	Use of lime, poison gases, etc.	N. J. Agr. Exp. Sta., Dept. of Water & Sewage Research, New Brunswick, N. J.
162	Sludge	Absorption capacity and removal of water from different types of sludges.	N. J. Agr. Exp. Sta., Dept. of Water & Sewage Research, New Brunswick, N. J.

Survey of Industrial Waste Research Problems

No.	Title of Project	Description	Investigator, Organization
163	Biochemical Oxygen Demands of Industrial Waste	A study of the natural rates of biochemical oxidation of some of the new industrial wastes.	Chemical Laboratory, U.S.P.H.S. Water and Sanitation Investigations, Cincinnati, Ohio.
164	Settling Anthracite Coal Dust	Study on separation and removal of fine coal dust and solids from breaker wash waters produced in preparation of coal.	Evan Evans, Chairman Anthracite Coal Com. and General Manager Lehigh Navigation Coal Co., Lansford, Pa., and Pa. Dept. of Health.
165	Studies and Treatment of Phenol, Formaldehyde and Resinous Wastes	Recovery of phenols and reduction of pollution load by physical and biochemical processes.	W. H. and L. D. Betz, Chem. Engineers, Philadelphia, Pa.
166	Study on Settling of Blast Furnace Scrubber Waste Waters	To determine efficiency of new works for recovery of blast furnace dust in scrubber waste water by treatment in tray clarifier, concentrating the sludge by vacuum filtration and pugmill as a preparatory step to sintering.	Bethlehem Steel Company, Bethlehem, Pa.
167	Waste Problems of the Iron and Steel Industry	Study to develop an improved practical method for treatment of spent pickle liquors primarily for reduction of stream pollution—also involving economics of the problem.	Mellon Institute of Ind. Research, Pittsburgh, Pa. W. W. Hodge for Amer. Iron and Steel Industry.
168	Cyanide Wastes	Treatment of plating wastes containing cyanides by means of chlorine to destroy the cyanides.	Conn. State Water Commission, Hartford, Conn., Wesleyan Univ., Middletown, Conn.
169	Treatment of Cyanide Waste Waters from Electro Plating	Removal of toxic constituent.	Braidech and Barnes, Cleveland, Ohio.
170	Studies of Treatment of Plating Waste and Pickling Liquors	Reduction of stream pollution.	Albright and Friel, Inc., Philadelphia, Pa.

TABLE I.—*Continued*

No.	Title of Project	Description	Investigator, Organization
171	Research on Manufacture of Triple Superphosphate from Phosphoric Acid Trade Wastes	Recovery of a strong phosphoric acid containing considerable organic matter. Field tests demonstrate the superphosphate recovered was satisfactory for vegetable growth.	F. M. Majewski, Rohm and Haas Co., Bristol, Pa.
172	Treatment of Oilfield Brine for Use in Water Flooding Projects for the Secondary Recovery of Oil	The use of oilfield brines in waterflooding projects has been found to be quite successful in some areas. However, in other areas these brines must receive considerable chemical treatment to prevent them from clogging up the oil-producing horizon.	Peter Grandone, Bureau of Mines, U. S. Dept. Interior, in co-operation with the Kansas State Board of Health, Petroleum-Exp. Sta., Bartlesville, Oklahoma.
173	Filtration Research	To reduce oil attached to suspended matter.	Laboratory of the Atlantic Refining Co., Philadelphia, Pa.
174	Biological Treatment of Caustic Waste	To reduce B.O.D., taste and odor and toxicity.	Laboratory of the Atlantic Refining Co., Philadelphia, Pa.
175	Treatment of Mercaptan Wastes	To reduce odor and toxicity.	Laboratory of the Atlantic Refining Co., Philadelphia, Pa.
176	Treatment of Ammonium Polysulfide Wastes	To reduce characteristic turbidity and toxicity.	Laboratory of the Atlantic Refining Co., Philadelphia, Pa.
177	Explosives Wastes	Pilot plant experiments treating explosives wastes together with domestic sewage by equalization, recirculating tricklings filters and sedimentation.	Henry T. Ell, Newark, N. J. (Reporter).
178	Treatment of TNT Waste Waters	A study on the volume and character of waste waters, including effectiveness of evaporation and subsequent treatment.	C. H. Young, Pennsylvania Department of Health.
179	Study of Alpha TNT Wastes	A study of the changes in alpha TNT wastes resulting in the production of highly colored waters, and the possible treatment procedures for such waters.	Chemical Laboratory, U.S.P.H.S. Water and Sanitation Investigations Station, Cincinnati, Ohio.
180	Wastes from the Synthetic Rubber Industry	A survey of the quantities, analytical characteristics and population equivalents of the wastes discharged.	Chemical Lab., U.S.P.-H.S. Water & Sanit. Investigations Sta., Cincinnati, Ohio.
181	Treatment of Styrene and Butadiene Wastes	A laboratory study of the possibilities of treatment of styrene and butadiene wastes by sewage treatment methods.	Chemical Lab., U.S.P.-H.S. Water & Sanit. Investigations Sta., Cincinnati, Ohio.
182	Taste and Odor Problems of Butadiene Wastes	A laboratory study of the methods of removal of tastes and odors from river waters containing butadiene wastes, in water treatment plants.	Chemical Lab., U.S.P.-H.S. Water & Sanit. Investigations Sta., Cincinnati, Ohio.
183	Taste and Odor Problems of Styrene Wastes	A laboratory study of the methods of removal of tastes and odors from river waters containing styrene wastes, in water treatment plants.	Chemical Lab., U.S.P.-H.S., Water & Sanit. Investigations Sta., Cincinnati, Ohio.

TABLE I.—*Continued*

No.	Title of Project	Description	Investigator, Organization
184	Synthetic Rubber	Treatment of wastes from the manufacture of butadiene and styrene, used in the manufacture of synthetic rubber. Treatment to prevent stream pollution.	Metcalf and Eddy, Cons. Engs., Boston, Mass.
185	Treatment of Waste Waters from Synthetic Rubber Manufacture	A study to develop satisfactory treatment of butadiene and styrene waste waters through the removal of oil, reduction of B.O.D. and taste and odors.	Koppers United Company, Pittsburgh, Pa.
186	Utilization of Cryolite	Study of the use of cryolite (sodium fluoaluminate) in gypsy moth infested forest on water supply watersheds.	Scranton Spring Brook Water Service Co., Inc. and George D. Norcum.
187	Laundry Wastes	Treatment of laundry wastes by high-rate trickling filters.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.
188	Control and Evaluation of Milk Losses; Effectiveness of Dry Plant Practices	Minimizing milk losses requiring waste treatment in stream sanitation activities.	The Wisconsin State Board of Health, Bureau of San. Eng., Madison, Wisc.
189	Paper, Pulp, and Paper Board Wastes	Means of treatment, recovery and utilization of wastes resulting from the manufacture of pulp and paper products.	National Council of Stream Improvement of the Paper, Pulp and Paper Board Inds., 271 Madison Ave., N. Y. C.
190	Studies for Treatment of Paper Mill Wastes	Recovery of stock and reduction of pollution load.	Albright & Friel, Inc., Philadelphia, Pa.
191	Reclamation and Disposal of Sulfite Pulp Liquors	Continued study to improve methods of reclaiming or treating objectionable pollutional characteristics in waste sulfite liquor, soda liquor, deinking wastes and white water, including effects of pollution on Clarion River.	Castanea Paper Company, Johnsonburg, Pa.
192	Treatment of White Waters from Paper Mills	Recovery of stock and reduction of pollution load.	W. H. and L. D. Betz, Chemical Engs., Philadelphia, Pa.
193	Treatment of Rag Cooker Wastes	Elimination of pollution load.	W. H. and L. D. Betz, Chemical Engs., Philadelphia, Pa.
194	Paper Board Mill Wastes	Treatment of wastes from paper board mills by flocculation and sedimentation with and without chemicals.	Conn. State Water Commission, Hartford, Conn.; Wesleyan University, Middletown, Conn.
195	Tannery Wastes	Treatment of tannery wastes more especially for the reduction of sulfides in the final effluent.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.
196	Tannery Wastes	Treatment of calfskin tannery wastes. Treatment to meet certain requirements for disposal.	Metcalf and Eddy, Cons. Engs., Boston, Mass.
197	Textile Wastes	Treatment of textile wastes. Treatment to meet certain requirements for disposal.	Metcalf and Eddy, Cons. Engs., Boston, Mass.

TABLE I.—*Continued*

No.	Title of Project	Description	Investigator, Organization
198	Studies for Treatment of Textile Wastes	Recovery of grease and reduction of pollution load.	Albright & Friel, Inc., Philadelphia, Pa.
199	Textile Wastes	Treatment of wastes from cotton or wool dyeing and finishing and cotton printing processes by chemical precipitation.	Conn. State Water Commission, Hartford, Conn.; Wesleyan Univ., Middletown, Conn.
200	De-Inking Paper Mill Wastes	Treatment of paper mill wastes from de-inking processes for discharge into waterways.	Conn. State Water Commission, Hartford, Conn.; Wesleyan Univ., Middletown, Conn.
201	Treatment of Dye and Bleachery Wastes	Elimination of pollution load.	W. H. and L. D. Betz, Chemical Engs., Philadelphia, Pa.
202	Treatment of Strong Chemical Wastes by Biological Methods	Wastes containing cotton, solvent plasticizers and acids treated on recirculating trickling filters and the secondary sludge treated with aerobic digestion.	Henry T. Ell, Newark, N. J. (Reporter).
203	Wool Scouring Liquors	Treatment of wastes from wool scouring liquors, with recovery of grease. Treatment to prevent stream pollution.	Metcalf and Eddy, Cons. Engs., Boston, Mass.
204	Wool Scouring Waste Treatment	By means of hypochlorite.	H. A. Faber, New York City.
205	Rendering Plant Waste Treatment	Treat liquid and gas waste from rendering plant to reduce stream loading and odor nuisance.	Amer. Well Wks., Morning Sun, Iowa.
206	Waste from the Food Dehydration Industry	A survey of the quantities, analytical characteristics and population equivalents of wastes from beet, hominy, potato, etc., dehydration plants.	Chemical Lab., U.S.P.-H.A. Water & Sanit. Investigations Sta., Cincinnati, Ohio.
207	Studies of Wastes Produced in Processing and Dehydrating Vegetables	Determination of volume and characteristics of wastes; studies of treatment problems.	U. S. Pub. Health Service, Stream Pollution Investigation Sta. at Dehydration Plants in Minn. & Wisc.; Upper Mississippi River San. Agreement, Boards of Health, Commissioners and Engineers.
208	Potato Dehydration Plant Waste	Experiments in an attempt to evolve a method of satisfactorily stabilizing wastes from potato dehydration plants.	E. L. Lium, Cons. Eng. and Prof. Civil Engineering, Grand Forks, North Dakota.
209	Treatment of Lye Peel Waste from Potato Peeling	Use of nitric acid to neutralize caustic soda in waste lye liquor to produce sodium nitrate which will make oxygen available in the stream receiving the waste.	Wm. A. Ryan, Rochester, N. Y.
210	Study of Treatment of Sauerkraut and Pickle Waste Waters		The Chester Engineers, Pittsburgh, Pa.

TABLE I.—*Continued*

No.	Title of Project	Description	Investigator, Organization
211	Treatment of Corn Canning Wastes	Determination of efficiency of corn canning waste treatment works, comprising screens, chemical treatment, sedimentation, recirculating high capacity trickling filter, storage lagoon and regulated discharge.	Blue Mountain Canneries, Inc., Martinsburg, W. Va.
212	Sugar Wastes	Laboratory and pilot plant studies employing aerobic and anaerobic digestion using special organisms and various admixtures of chemicals.	Causse Manufacturing Co., Bound Brook, N. J.
213	Yeast Wash Water	Pilot plant experiments on upflow digestion, high-rate and double filtration of yeast wash waters.	Anheuser Busch Co., Old Bridge, N. J.
		Survey of Stream Pollution Research Problems	
214	Stream Organisms	Comparative studies of the flora and fauna of various streams, together with the environmental characteristics of streams at points of maximum occurrence of various organisms.	J. B. Lackey, U.S.P.H.S. Water & Sanit. Investigations Station, Cincinnati, Ohio.
215	Lake Organisms	The relationship between organism occurrence, especially blooms, and lake fertilization.	J. B. Lackey, U.S.P.H.S. Water & Sanit. Investigations Sta., Cincinnati, Ohio.
216	Studies of Oxygen Depletion and Recovery Through Aeration and Other Factors	Obtain further basic knowledge on factors affecting oxygen depletion and recovery of streams from pollutional effects.	Wisconsin Committee on Water Pollution, Wisc. State Board of Health and cooperating industries on Wisc. River and other streams.
217	Toxic Effects of Various Wastes on Plankton Forms	To establish reliable methods for evaluating toxicity effects on plankton forms.	Laboratory of the Atlantic Refining Co., Philadelphia, Pa.
218	Toxic Effects of Various Oil Wastes on Fish Life	To establish a reliable method for evaluating toxicity in fish.	Laboratory of the Atlantic Refining Co., Philadelphia, Pa.
		Survey of Research on Analytical Methods	
219	Determination of Dissolved Oxygen	A comparison of analytical procedures for the determination of D.O. in the presence of interfering substances.	Chemical Lab., U.S.P.-H.S. Water & Sanit. Investigations Station, Cincinnati, Ohio.
220	B.O.D. Determination	Effect of high concentration of free ammonia on the B.O.D. of activated sludge effluent.	F. Nussberger, N. Y. C.
221	Method of Oil Determination in Waste Waters	Determination of oil in oil field and refinery waste waters.	Richard Pomeroy and H. D. Kirchman, Pasadena, Cal.
222	Chlorine Demand Determination	By amperometric titration method.	A. E. Griffin, New York City.
223	Determination of TNT in Waste Waters	Development of methods of analysis for the determination of the various forms of TNT in waste waters.	Chemical Lab., U.S.P.-H.S. Water & Sanit. Investigations Sta., Cincinnati, Ohio.

TABLE 2.—*Problems Requiring Investigation*

No.	Title of Project	Description	Suggested By
		SEWAGE	
32	Grease Removal	Study of sulfuric acid for grease removal in those wastes showing increased grease removed by chlorination on the theory that it could be the HCl produced and introduced by chlorination which reacts with soaps.	P. D. McNamee, Dist. of Col.
33	Grease Removal	Further study on the effect of chlor-aeration on grease removal.	George E. Symons, New York City.
34	Chlorine	Effect of chlorine on the aeration of sewage and organic wastes.	Wm. A. Ryan, Rochester, N. Y.
35	Sedimentation	Improvement of sedimentation in circular tanks by baffle arrangements.	George E. Symons, New York City.
36	Sludge Digestion	Determination of percentage of various organic wastes that can be digested with sewage sludge in heated and unheated digesters.	Wm. A. Ryan, Rochester, N. Y.
37	Sludge Digestion	Effect of mechanical and physical factors on sludge digestion.	E. J. Kilcawley, Rensselaer Poly. Inst., Troy, N. Y.
38	Sludge Digestion	Further study of the presence of a volatile iron compound evolved during sludge digestion.	P. D. McNamee, Dist. of Col.
39	Trickling Filters	Effect on filter efficiencies of recirculating humus tank underflow as applied to sewage filter.	C. H. Young, Penn. Dept. of Health, Meadville, Pa.
40	Activated Sludge	Factors involved in sedimentation, particularly inlet velocities, velocity of approach to the outlet wiers, length of wiers and their location.	Langdon Pearse, Chicago, Ill.
41	Activated Sludge	Development of a simple, cheap container built for removal of diffuser plates.	Langdon Pearse, Chicago, Ill.
42	Sludge Filtration	Study of factors which affect filter cloth.	George E. Symons, New York City.
43	Activated Carbon	Determine the effect of activated carbon added to digested sludge on ground dried sludge for lawn top dressing, and its effectiveness and odor control.	Wm. A. Ryan, Rochester, and L. A. Marshall, Geneva, N. Y.
44	Fertilizer	Study the possible use of chemically de-watered flash dried sludge for fertilizer.	George E. Symons, New York City.
45	Recovery of Bacteria and Parasitic Organisms from Soil	Recovery of pathogenic bacteria or parasitic organisms or eggs from agricultural soil treated with digested sewage sludge.	Conn. State Dept. of Health, Hartford, Conn., Bureau of Sanitary Engineering.
46	Growth-Promoting Agents	Isolation of the growth-promoting agents of sewage sludge.	P. D. McNamee, Dist. of Col.

TABLE 2.—*Continued*

No.	Title of Project	Description	Suggested By
		INDUSTRIAL WASTES	
47	Disposal of Industrial Wastes Treatment Sludges	Dewatering of sludges on drying beds, vacuum filtration, etc., produced on chemical treatment of various industrial wastes such as iron, textile, copper and brass.	Conn. State Water Commission, Hartford, Conn.
48	Treatment of Synthetic Rubber Waste Waters	Method for treating waste waters resulting from polymerizing butadiene and styrene in the manufacture of synthetic rubber.	Penn. Dept. of Health, Harrisburg, Pa.
49	Treatment of Brewery Wastes by Activated Sludge	The modification of sewage activated sludge treatment to handle brewery wastes.	R. I. Dept. of Health, Providence, R. I., Div. of San. Engineering.
50	Laundry Wastes Treatment in Large Army Camps	In normal municipal practice, laundry wastes constitute only a fraction of sewage flow. Discharge from large army laundries may constitute a large percentage of total sewage, causing difficulty and odor nuisances, particularly in warmer climates.	Capt. A. B. DeWolf, Corps of Engineers, U. S. Engineers Office, Jacksonville, Fla.
51	Textile Wastes	Satisfactory treatment of textile wastes for discharge to streams or sewage treatment plants.	N. H. Dept. of Health, Concord, New Hampshire, Div. of Chemistry and Sanitation.
52	Cotton Finishing Plant Wastes	Treatment of cotton finishing plant wastes containing kier liquors on high-rate trickling filters.	R. I. Dept. of Health, Providence, Rhode Island, Div. of Sanitary Engineering.
53	Treatment of Sewage and Cotton Finishing Plant Wastes	Treatment of combined sewage and cotton finishing plant wastes.	R. I. Dept. of Health, Providence, Rhode Island, Div. of Sanitary Engineering.
54	Wool Wastes	Treatment of partially degreased wool scouring wastes.	R. I. Dept. of Health, Providence, Rhode Island, Div. of Sanitary Engineering.
55	Paper and Pulp Wastes Treatment	The wastes from sulfate and sulfite processes are seriously menacing the fish industry, causing stream, lake, and bathing beach pollution. Post-war expansion is expected to increase difficulties.	W. Austin Smith, Smith and Gillespie, Arch. and Eng., Jacksonville, Fla.
56	Paper Mill White Water	Comparative study of efficiencies of various types of white water save-alls (plain sedimentation, chemical coagulation, atmospheric flotation, vacuum flotation and tray clarifier) to determine efficiencies of removal of solids to permit maximum reuse of effluent and use of removed solids.	Penn. Dept. Health, Harrisburg, Pa.

TABLE 2.—*Continued*

No.	Title of Project	Description	Suggested By
57	Paper Mill Wastes	Treatment of paper mill wastes from the manufacture of cigarette paper from flax straw.	Mass. Dept. of Pub. Health, Lawrence Exp. Sta., Lawrence, Mass.
58	Tannery Wastes	Determination of results of various methods of treatment satisfactory for discharging them to streams.	Weston and Sampson, Cons. Engineers, Boston, Mass.
59	Tomato Cannery Wastes	A waste "successfully" treated by biological methods has very unsatisfactory aspects in practice.	Henry T. Ell, Newark, N. J.
60	Citrus Wastes	Methods are available to process citrus peel for feed. Citrus juice and waste (pressed) citrus oil can be taken care of by evaporation, with the production of citrus molasses, but is only economical for large plants. Needed, satisfactory, inexpensive method of treatment for small plants.	John H. Ruge, U. S. Dept. of Agr. W. F. A. Office, Dunedin, Fla.
61	Food Dehydration Plant Wastes	Biological treatment of these wastes which normally have the B.O.D. strength of domestic sewage and contain generally convertible starch, is of academic and practical interest.	Henry T. Ell, Newark, N. J.
62	Potato Dehydration Plant Waste	To develop a method of treating potato dehydration plant wastes to render them stable or reduce the strength sufficiently so such wastes can be discharged and treated with municipal sewage.	K. C. Lauster, State Dept. of Health, Bismarck, North Dakota.
63	Creamery Wastes	Treatment of creamery wastes on high-rate and/or recirculating trickling filters to produce stable effluents, which has not been accomplished in the majority of cases.	Henry T. Ell, Newark, N. J.
		STREAM POLLUTION	
		No problems reported.	
		ANALYTICAL METHODS	
64	Determination of Suspended Solids in Sewage and Sewage Effluents	Filtration method based on difference between total solids and dissolved solids as compared to other methods such as Gooch crucible, etc.	Conn. State Dept. of Health, Hartford, Conn., Bureau of Sanitary Engineering.
65	Suspended Solids Determination	Develop a standard technique that will determine suspended solids, *i.e.*, compare centrifuging with filtering—effect of thickness of mat, etc.	George E. Symons, New York City.
66	Solids Determination	Develop equipment for determining the percentage solids in sludge from sp.g. variations.	George E. Symons, New York City.

TABLE 2.—*Continued*

No.	Title of Project	Description	Suggested By
67	Methods	Development of sound, simple and rapid tests indicating the efficiency of sewage treatment plants to fill the need of smaller plant operators.	Henry T. Ell, Newark, N. J.
68	B.O.D. of Organic Wastes	Proper determination of the total B.O.D. of organic wastes.	Wm. A. Ryan, Rochester, N. Y.
69	Grease	Comparative data on determination of grease by different methods.	George E. Symons, New York City.
70	Chlorination	Relation of immediate chlorine demand to total chlorine demand in sewage.	George E. Symons, New York City.
71	Chlorination	Relation of chlorine potential to chlorine demand in sewage.	George E. Symons, New York City.
72	Chlorination	Can hypochlorite be used for determining chlorine demand instead of chlorine water?	George E. Symons, New York City.

working on industrial waste problems would keep in mind possibilities of by-product recovery, but would not be handicapped in devising methods of treatment.

Comments received on the listing of problems requiring investigation indicate that the listing has already stimulated investigations. There is no doubt that further stimulation will be felt as time goes on.

The Research Committee performs a function in the listing of the projects underway and those requiring study. It is ready to receive suggestions and assist in finding investigators equipped to handle problems; it cannot, however, take the initiative to perform the work or guarantee that studies will be undertaken or completed.

PRELIMINARY REPORT ON EFFECT OF CYANIDE CASE HARDENING, COPPER AND ZINC PLATING WASTES ON ACTIVATED SLUDGE SEWAGE TREATMENT

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and
Fish Division of the University Museums, University of Michigan, Ann Arbor, Michigan

The use of the cyanide case hardening process in industry has increased quite rapidly in recent years, particularly since the beginning of the war. This process involves the use of more or less concentrated quantities of sodium cyanide, which under certain conditions may have to be wasted either to the sewerage systems or directly to a stream. However, the poisonous nature of the sodium cyanide and cyanide salts formed in the cyanide bath makes it undesirable to discharge this material in the concentrated form into either sewage plant or stream without pretreatment at the industrial plant. In one of the proposed methods of pretreatment, lime-sulfur or calcium polysulfide is used (1) which changes the sodium cyanide to sodium thiocyanate. The resulting waste thus consists of a relatively high concentration of sodium thiocyanate, calcium polysulfide and small amounts of sodium cyanide. Small quantities of copper or zinc compounds sometimes may also be present in the case of treated copper or zinc electroplating solutions.

As an example, the treated case hardening bath known as the du Pont Carburizing Salt bath may contain from 10–60 p.p.m. NaCN, 30,000–50,000 p.p.m. NaCNS, and excess calcium polysulfide or lime sulfur in variable quantities. The treated copper plating solution, according to analyses furnished by the Electrochemicals Department of the E. I. du Pont de Nemours & Co. Inc., may contain as high as 100 p.p.m. NaCN, 175,000 p.p.m. NaCNS and excess polysulfide. The treated zinc plating solution may contain 100 p.p.m. NaCN, 110,000 p.p.m. NaCNS and excess polysulfide.

While the sodium cyanide content of all of these treated wastes is reduced to such small amounts that by normal dilution the toxicity is possibly reduced to insignificant proportions as far as the effect on sewage treatment processes is concerned, the by-products, namely NaCNS and excess polysulfide, are present in concentrations that might affect the sewage treatment processes, provided the wastes were so disposed. In addition, in the case of the treated plating solutions, copper and zinc might possibly be present in sufficient amounts to be a toxicity factor.

In consequence, studies were set up to investigate the effect of these treated wastes on aerobic biological processes of sewage treatment. The aerobic type of treatment selected as being most sensitive to these wastes was activated sludge.

These investigations were financed by the Electrochemicals Department of E. I. du Pont de Nemours & Company, Inc., Niagara Falls, New York, as a contribution by this company toward the solution of problems relating to stream pollution. The work was done at the University of Michigan as a project sponsored by the American Wildlife Institute. Most of the chemical analyses were performed by Howard Stroud, Research Assistant, Department of Public Health Engineering, School of Public Health, University of Michigan. A later report covering work now in progress will relate to the effect of lime-sulfur treated waste cyanide solutions on the anaerobic sludge digestion process and also to the effect of the activated sludge process on the sodium thiocyanate content in the sewage.

Method of Investigation

The study of the effect of these wastes on the activated sludge process was approached through laboratory studies carried on under carefully controlled conditions designed to approximate as closely as possible practical plant operation procedures.

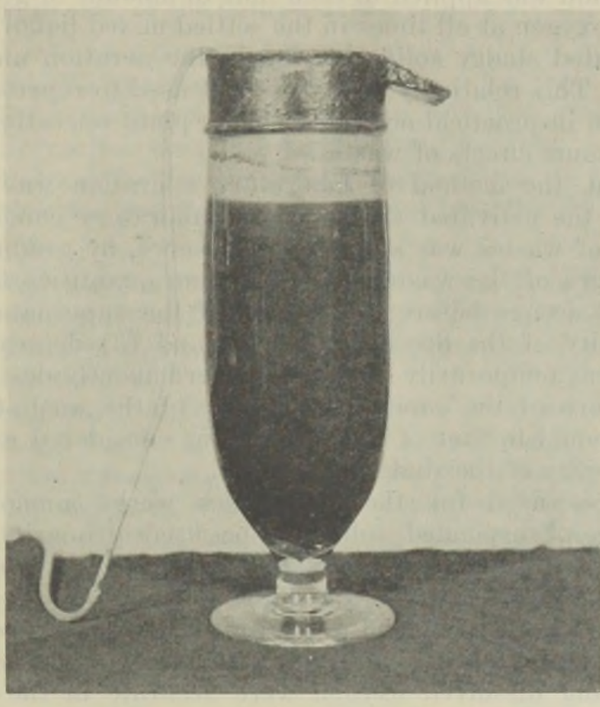

Fig. 1.—Type of aeration units used in investigation.

Samples of activated sludge were obtained from the Ann Arbor activated sludge plant and placed in a series of five-liter fish-hatching jars equipped with "Aloxite" air diffuser balls (Fig. 1). This original batch of activated sludge was used throughout each experiment. Routine operation of the activated sludge units consisted of daily withdrawal of the supernatant liquor down to an amount equal to 20 per cent of the original volume. The liquor was replaced by settled (primary treated) sewage, likewise obtained from the Ann Arbor sewage plant. This operation was carried on for about 1 week at the beginning of each experiment to allow the sludge to stabilize under laboratory conditions, as well as to determine the normal variation in the material before wastes were added. After this initial period of stabilization and observation, daily additions of the wastes to be studied were started. The quantity of each waste added was increased on each succeeding day until the analyses indicated impairment of the quality of the supernatant liquor as compared to the control accompanying the group of wastes. The control consisted of one unit operated exactly as were all others in the group, except that no wastes were added. When serious impairment of the supernatant liquor quality was reached in any one of the waste-treated units, the addition of waste was stopped. Aeration and daily addition of settled sewage was continued for a longer period, however, in order to observe the ability of the activated sludge to recover after receiving excessive dosages of the waste materials. Aeration was applied to each unit in amount to give 4–8 p.p.m. of dissolved oxygen at all times in the settled mixed liquor. The quantity of activated sludge solids carried in the aeration units averaged 1,300 p.p.m. This relatively low figure was used to represent the probable minimum in practical activated sludge plant operations and to allow for maximum effects of wastes.

In general, the method of laboratory operation was designed to (1) stabilize the activated sludge under laboratory conditions before the addition of wastes was started, (2) observe, by gradually increasing the dosages of the wastes, the maximum quantities that could be added to the sewage before the quality of the supernatant liquor or the settleability of the floc was affected, and (3) determine whether the process was temporarily impaired or permanently destroyed by the wastes. Return of the supernatant liquor of the waste-treated units to a quality equal to that of the control was considered as demonstration of the ability of the sludge to recover.

The indices used for these purposes were: ammonia-nitrogen, nitrate-nitrogen, suspended solids to be used primarily to indicate possible disintegration of the activated sludge floc, hydrogen ion concentration, and settleability of the sludge floc.

Biochemical oxygen demand measurements were not included in the test indices because it was found that none of the standard procedures for determining dissolved oxygen were accurate in the presence of NaCNS. Any of the standard dissolved oxygen methods in the presence of this salt gave a false B.O.D. more or less in proportion to the amount of salt present. This inaccuracy was checked by gasometric analyses.

All analyses were made on the supernatant sewage liquor after six hours aeration followed by one hour settling.

Methods of Analysis

The tests used in these investigations were made according to the A. P. H. A. *Standard Methods of Water and Sewage Analysis,* 1941 edition, with modifications indicated therein as being necessary for the character of the wastes being studied.

Before using any of the selected tests in the investigation, checks were made to determine the degree of interference, if any, of the various wastes. The reliability of each test was checked by comparing duplicate samples; one group without the waste and the other containing the waste in the maximum quantity used in the experiment. Where any interference was apparent, modifications were developed to neutralize the interference of the specific substances.

Results

The detailed results of the studies on each individual waste are shown in Figs. 2 to 7 inclusive. The dotted line represents the values obtained from the supernatant liquor of the activated sludge unit receiving the waste. The solid line gives the values in the supernatant liquid of the control corresponding to the waste treated sample. The wastes studied in each of the figures were as follows:

Fig. 2. NaCN in commercial form.
Fig. 3. NaCNS in commercial form.
Fig. 4. Polysulfide-treated carburizing salt bath residue solution.
Fig. 5. Polysulfide-treated copper plating solution.
Fig. 6. Polysulfide-treated zinc plating solution.
Fig. 7. Calcium polysulfide solution, prepared from lime and sulfur.

The treated wastes corresponding to those which, in greatly diluted form, would be received at the plant from the industry are No. 4, the carburizing solution, No. 5, the copper plating solution and No. 6, the zinc plating solution.

The others, Nos. 2, 3, and 7, represent the basic constituents which are present in greater or in lesser amounts in wastes, Nos. 4, 5, and 6. The investigation was designed in this manner to allow an evaluation of the effect of the wastes in either pure or combined forms, as well as an evaluation of the effect of wastes actually discharged, in terms of the basic constituents.

Compositions of the polysulfide-treated cyanide solutions were as follows: *

Constituent P.P.M.	No. 4 Carburizing Salt Bath	No. 5 Copper Plating	No. 6 Zinc Plating
NaCN	60	110	120
NaCNS †	55,000	102,000	104,000
Calcium Polysulfide	Excess	Excess	Excess

* Compositions furnished, with the samples, by the Electrochemicals Department of the E. I. du Pont de Nemours Company, Inc., Niagara Falls, New York. These analyses were run before shipment of the wastes. There is some indication that their composition may have changed slightly between the time of analysis and the time of experiments.

[illegible] were calculated by the du Pont Company.

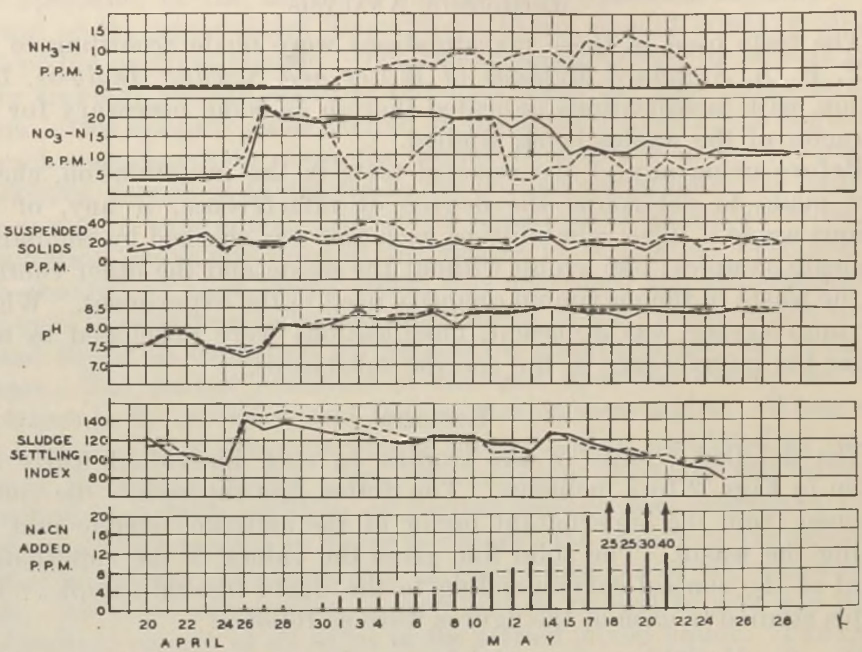

FIG. 2.—Effect of NaCN.

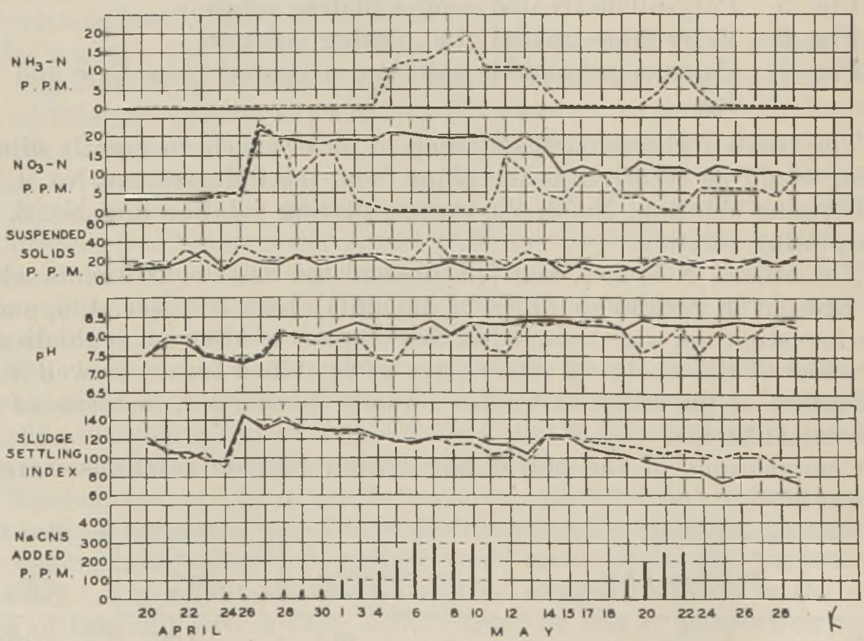

FIG. 3.—Effect of NaCNS.

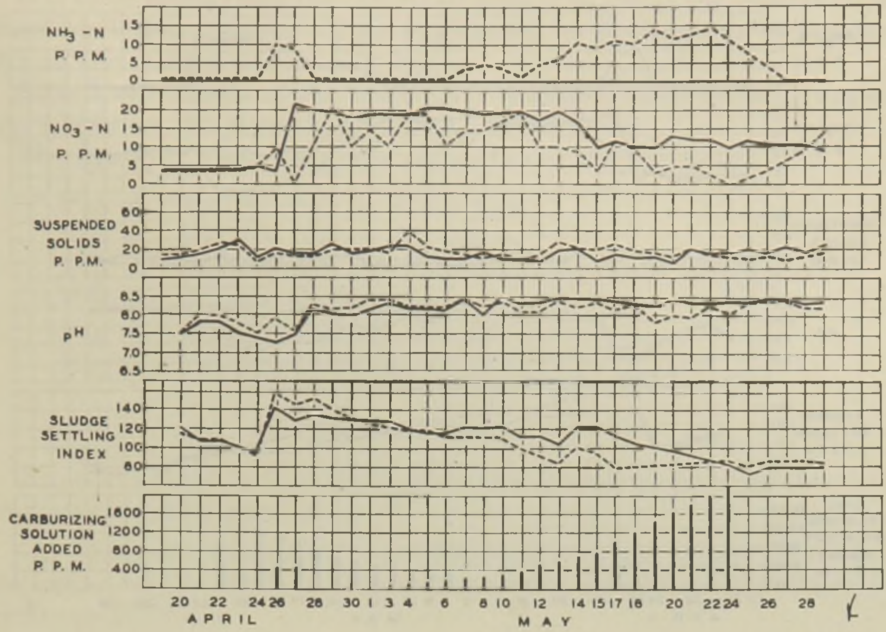

FIG. 4.—Effect of carburizing solution.

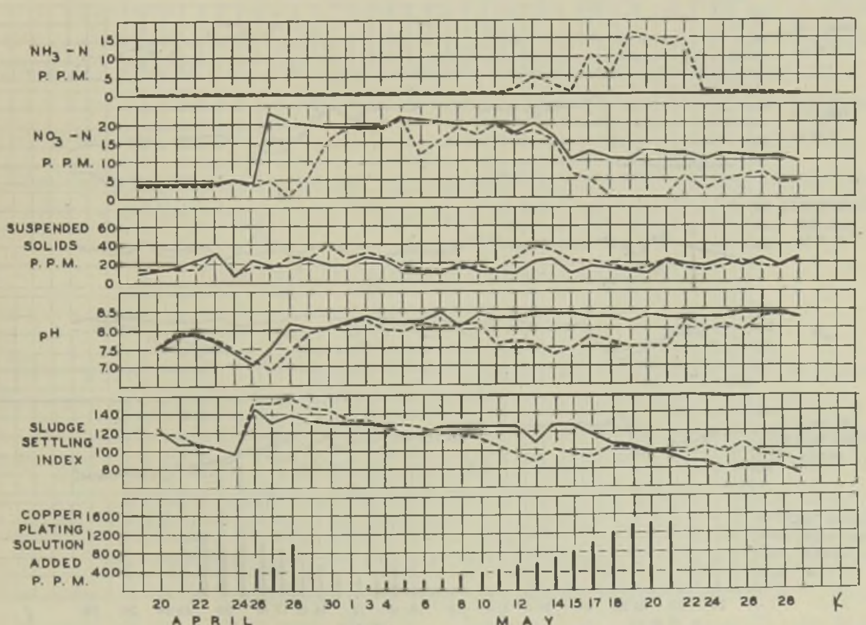

FIG. 5.—Effect of copper plating solution.

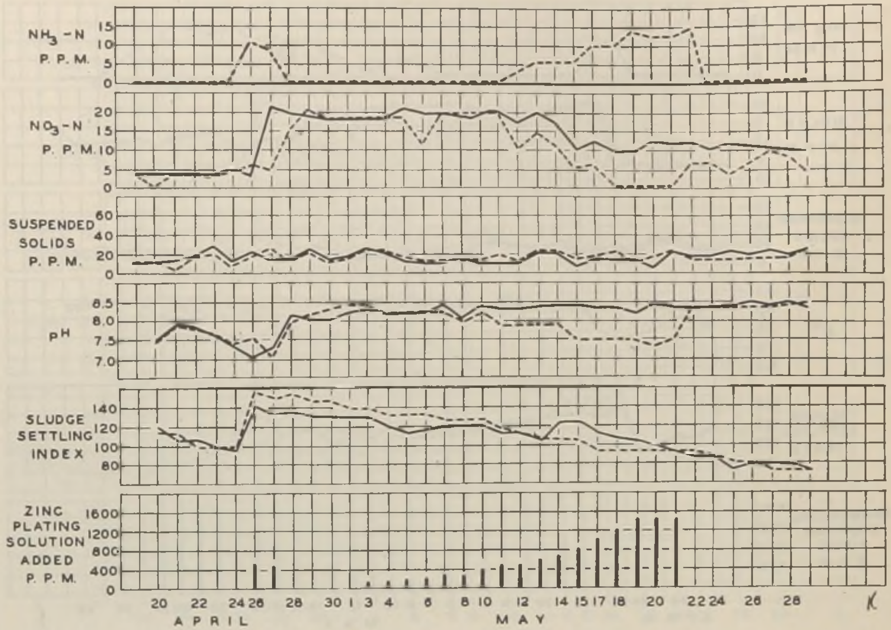

FIG. 6.—Effect of zinc plating solution.

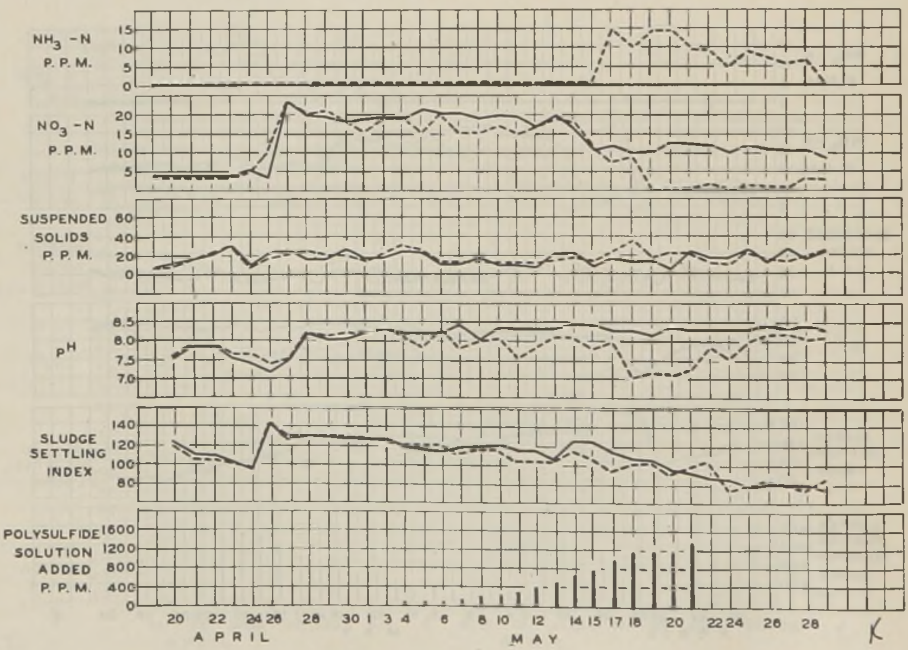

FIG. 7.—Effect of polysulfide.

It is to be noted from the results in Figs. 2 to 7 that the control supernatant varied in quality. This was caused by fluctuations in the character of the sewage added each day.

Significant effects of the wastes are indicated only when divergence occurs between the control and waste-treated values.

The range of waste loadings added to the sewage were:

Fig. 2. NaCN—0.25 to 40.0 p.p.m.
Fig. 3. NaCNS—25 to 250 p.p.m.
Fig. 4. Carburizing salt bath solution—50 to 1,800 p.p.m.
Fig. 5. Copper plating—50 to 1,400 p.p.m.
Fig. 6. Zinc plating—50 to 1,400 p.p.m.
Fig. 7. Calcium polysulfide—50 to 2,200 p.p.m.‡

Discussion of Results

As an approach to field application, the data have been compiled and interpreted with respect to:

(*a*) Minimum amount of waste causing a change in the more sensitive indices of purification performance, namely, ammonia-nitrogen and nitrate production.

(*b*) Minimum amount of waste causing a reduction in suspended solids removal from the sewage or disintegration of the activated sludge floc.

(*c*) Minimum amount of waste causing an effect on the settleability of the activated sludge, the sludge index recommended by *Standard Methods of Water and Sewage Analysis* being used for this purpose.

(*d*) The ability of the activated sludge to recover from the influence of the wastes if affected.

The following discussion of each waste is directed along these lines. The effects of the wastes are likewise summarized in Table I.

Sodium Cyanide—Figures 2 and 8

Nitrification

The results show that from 2 to 3 p.p.m. of sodium cyanide caused a decrease in nitrate formation and ammonia reduction. Ammonia in the supernatant increased with increasing quantities of sodium cyanide above these amounts. Decrease in nitrate formation did not, however, consistently follow with increased additions of cyanide. Stabilization at approximately 5 p.p.m. of NO_3–N appeared with 3 to 4 p.p.m. of NaCN. This was followed by an increase in nitrates to an amount equal to the control with the addition of 6 p.p.m. of NaCN and remained equal to the control up to 8 p.p.m. NaCN. Thereafter a decrease occurred to the previous level of approximately 5 p.p.m. NO_3–N. This fluctuating cycle continued until the end of the experiment. At no time, however,

‡ Expressed in terms of parts of a saturated solution of polysulfide per million parts of sludge.

TABLE I.—*Summary of Effects of Wastes*

Sample No.	Waste	NaCNS Equiv. %	Nitrification: Ammonia—N: Occurred at	Nitrification: Ammonia—N: Maximum at	Nitrification: Nitrate—N: Decreased at	Nitrification: Nitrate—N: Destroyed at	Suspended Solids in Supernatant: Increased at	Suspended Solids in Supernatant: Seriously Increased at	pH: Changed at	Sludge Settling Index: Changed at	Time for Complete Recovery
			P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.,m	P.p.m.	P.p.m.	Days
2	NaCN	0	2*	6	2	over 40	1	no serious increase	no effect	no practical change	2
3	NaCNS	100	200	300	50	200	200	no serious increase	50	no practical change	1–2
4	Carb. Sol.	3.7	250–500	2,000	200–500	2,200	not increased	no serious increase	effect slight	no practical change	2–3
5	Cop. Plat. Sol.	17.5	500–800	1,400	500–800	1,200	400	no serious increase	400	no practical change	1–3
6	Zinc Plat. Sol.	11.0	500	1,400	500	1,200	not increased	no serious increase	400	no practical change	1–3
7	Ca. Poly. Sol.	0	1,000*	1,000	1,000	1,200	1,000	no serious increase	250	no practical change	2–4

* Theoretical point of waste.

was nitrification completely destroyed, even with sodium cyanide additions as high as 40 p.p.m. The reason for this fluctuating cycle and the maintenance of some nitrate production is not known at this writing. There is some evidence to indicate that either a certain immunity develops in the nitrate forming organisms, or new types of organisms develop. In any event, it appears that the NaCN possesses much less power to affect nitrification than is commonly assumed. This probably is related to the fact that hydrogen cyanide is given off during the process of aeration, the NaCN apparently being hydrolyzed by the air stream or by biological action, or both. Accumulation of HCN in the sewage liquor is prevented by the aeration process.

In this connection, Perekalin (2) found that KCN was rapidly driven out of solution by aeration, 75 per cent of an initial 15 p.p.m. being volatilized in 30 minutes, without appreciable oxidation.

Suspended Solids

The effect of NaCN on suspended solids was negligible up to and including 40 p.p.m. of NaCN. This indicates not only lack of effect on removal of suspended solids from the supernatant liquor, but also lack of disintegration of activated sludge solids. Increase of turbidity of the supernatant liquor was noticeable at 2 p.p.m of NaCN. This increased turbidity, however, failed to be reflected in increased quantities of suspended solids, measured by Gootch crucible.

Sludge Settling

The settleability of the activated sludge was unaffected by any amount of the NaCN up to 40 p.p.m., the maximum for the experiment.

Recovery

The ability of the activated sludge to recover from the effects of the NaCN treatment is demonstrated in the period after addition of the cyanide was stopped. In approximately two days the effects of the NaCN disappeared, as measured by those purification indices used.

Sodium Thiocyanate—Figures 3 and 8

Nitrification

Depression of nitrification began with the addition of 50 p.p.m. of NaCNS. Total destruction of nitrate production did not occur, however, until 200 p.p.m. of NaCNS had been added. NH_3–N occurred in the supernatant at this latter dosage and increased with further additions of the thiocyanate. Nitrate production was prevented by all amounts of the thiocyanate above 200 p.p.m.

Suspended Solids

Suspended solids in the supernatant were relatively unchanged by additions of the NaCNS. Turbidity occurred with a dosage of 50 p.p.m. of the NaCNS. This increased turbidity was apparently due, however, to the character of dispersion of the solids particles, rather than to greater quantities of suspended solids.

Settleability of Activated Sludge

NaCNS in amounts from 50 to 300 p.p.m. failed to have any practical effect on the settleability of the sludge floc.

Recovery

Rapid recovery of the activated sludge occurred after the period of depression by NaCNS. Nitrate production recovered to a quality close to that of the control within one day after the addition of waste was stopped. This quick recovery was shown after each period of waste dosage.

Carburizing Solution—Figures 4 and 9

Nitrification

The effect of the polysulfide-treated carburizing solution on nitrification was rather indefinite until comparatively large quantities of the waste were added. On an average, the nitrate-nitrogen ran somewhat below the control beginning with the first addition of the waste. Some depression below the control level persisted throughout the experiment. Total destruction of nitrate production did not occur, however, until 2,200 p.p.m. of carburizing solution had been added. NH_3–N in the supernatant began to definitely increase with addition of 300 to 400 p.p.m. of the waste.

Suspended Solids

Suspended solids in the settled sludge liquor were unaffected by any amount of the waste between 50 and 2,200 p.p.m.

Settleability

The settleability of the sludge floc was not definitely or consistently affected by the carburizing solution. A denser and quicker settling floc was formed in the waste-treated sample with dosage between 50 and 1,000 p.p.m., but no further increase of density occurred with higher amounts of waste.

Recovery

Any effect the waste had on the purification performance of the activated sludge was only temporary. Within 2 or 3 days after the addition of waste was stopped, the quality of the supernatant liquor returned to normal.

Copper Plating Solution—Figures 5 and 9

Nitrification

Nitrification in the presence of copper plating solution was not materially reduced until 800 to 1,000 p.p.m. of the material had been added. At 1,200 p.p.m. it was completely destroyed. Ammonia-nitrogen in the supernatant liquor increased to a maximum level coinciding with the point of minimum nitrate production.

Suspended Solids

Amounts of suspended solids in the supernatant were relatively unaffected by all amounts of the copper plating solution up to 1,400 p.p.m., the maximum quantity added.

Settleability of Activated Sludge

Settleability of the activated sludge was not definitely or consistently affected by the waste. There was some tendency for a lighter and slower settling sludge between 400 and 800 p.p.m., but at lesser and greater dosages the settling characteristics of the sludge remained about the same as the control.

Recovery

Recovery of the supernatant liquor quality was practically complete in one day. Ammonia-nitrogen disappeared in two days. Nitrate production began to increase at a slow rate immediately, after discontinuance of the wastes.

Zinc Plating Solution—Figures 6 and 9

Comparison of the data for the zinc plating solution almost duplicates that of Fig. 5 (copper plating solution). Nitrate production was affected at 500 p.p.m. of zinc plating solution and disappeared at 1,200 p.p.m. Suspended solids and settleability of the floc were relatively unaffected. Recovery with respect to NH_3–N occurred within two days, but return to normal nitrate production was at a slower rate.

The close similarity of the effect of these two wastes might be expected on the basis of their NaCNS content; the percentage of this component being approximately the same in both. The main difference in the two wastes was in possible small traces of copper and zinc. The polysulfide-treatment process apparently eliminated any serious toxicity of these two metals on sewage micro-organisms.

Calcium Polysulfide—Figures 7 and 8

Nitrification

The effect of calcium polysulfide on nitrification was practically negligible for all amounts less than 1,200 p.p.m. of waste. In that quantity nitrification was destroyed. Ammonia-nitrogen appeared with 1,000 p.p.m. of the polysulfide solution.

Ayyar (3) found that nitrification by activated sludge was inhibited by the presence of sulfur, but that ammonification, supposedly brought about largely by fungi, was not seriously affected.

Suspended Solids

Suspended solids removal was unaffected by all amounts of the waste between 50 and 1,400 p.p.m.

Settleability of Activated Sludge

Settling characteristics of the activated sludge were unaffected by all amounts of the waste used in the experiment.

Recovery

Recovery of nitrification was slower with this waste than those previously studied. This slower recovery rate may be related to the high quantities of sulfur precipitated from the calcium polysulfide and absorbed in the sludge floc. The precipitation of this sulfur was positive and immediate. In less than an hour after the polysulfide was added to the activated sludge, the color of the sludge changed from a normal dark brown to a yellowish chalk color. With continued aeration the color changed back to normal, probably indicating oxidation of the sulfur to soluble form. In spite of the large quantity of sulfur absorbed by the floc, its effectiveness was not impaired until 1,200 p.p.m. of the waste had been added.

General Discussion

It appears from these studies that certain amounts of the polysulfide-treated carburizing, copper and zinc plating wastes, in the form as discharged by the industry, can be tolerated in the sewage before the activated sludge process is seriously affected. Of the six wastes studied, only the polysulfide-treated carburizing salt bath residue solution, copper plating solution and zinc plating solution represent the industrial wastes as such. The other three, sodium cyanide, sodium thiocyanate and calcium polysulfide, are basic constituents of the above treated wastes and are present in diluted form only, as in the amounts previously given.

The limit of tolerance of the activated sludge process for the three industrial wastes is summarized by the following table:

Limit of Tolerance by Activated Sludge

Waste Solution	Nitrification		Suspended Solids Affected (p.p.m.)	Sludge Settling Affected (p.p.m.)
	Destroyed (p.p.m.)	Affected (p.p.m.)		
Carburizing	2,200	500	over 2,200	over 2,200
Copper Plating	1,200	500	over 1,200	over 1,200
Zinc Plating	1,200	500	over 1,200	over 1,200

It should also be noted that these results were obtained with the use of a minimum concentration of activated sludge, equivalent to the smallest amounts of solids ordinarily encountered in activated sludge plants. Solids in the mixed liquor did not exceed 1,500 p.p.m. during the entire investigation, and at times dropped as low as 1,200 p.p.m. This low solids concentration was purposely used to show maximum practical effects of the wastes. Later studies * on these wastes with higher concentrations of sludge indicate that larger amounts of the wastes can be tolerated with the use of greater quantities of activated sludge.

It is also obvious that with provision at the industrial source for holding back the waste materials and for distribution of discharge over a period of time, a comparatively small sewage flow could be made to handle the discharges from a relatively large industrial waste discharge, provided pretreatment of the wastes with polysulfide was practiced.

Another point of practical interest is the fact that incidental discharge of these wastes in concentrations beyond the amount which

* Date not given above.

could ordinarily be tolerated by the process would only temporarily disrupt the quality of the plant effluent. This is indicated by the quick return to normalcy of the settled liquor after discontinuance of the wastes.

From these observations it also appears that NaCN, while definitely harmful to the activated sludge process, is not nearly so destructive as might be assumed from its reputed toxic nature. The effects were demonstrated mainly by an increase in NH_3–N and a deression in NO_3–N production. Serious dispersion of sludge floc or interference with suspended solids removal from the supernatant did not occur in appreciable amount, in this instance, with 40 p.p.m. of NaCN. Recovery was also quite rapid.

The data obtained are quite consistent throughout in showing that none of the wastes studied had any noticeable effect on the settling characteristics of the activated sludge.

Summary

Studies were conducted on the effect of polysulfide-treated cyanide case hardening, copper plating, and zinc plating wastes on the activated sludge process of sewage treatment. The basic constituent of the untreated wastes, namely, sodium cyanide (present also for some time in small amount, in the treated wastes), and the basic constituents of the treated wastes (sodium thiocyanate and calcium polysulfide), were investigated separately.

The procedure followed consisted of operating activated sludge aeration and settling units in the laboratory in a manner simulating as closely as possible actual plant operation conditions. Activated sludge was used, with daily renewal of sewage and daily addition of increased doses of the waste materials.

Laboratory tests included those necessary to secure data on the effects of the wastes with respect to: (*a*) nitrification, (*b*) suspended solids in the supernatant liquor, (*c*) settling characteristics of the activated sludge, and (*d*) time for recovery of the activated sludge process after dosing ceased.

The results showed that certain amounts of the polysulfide-treated case hardening, copper plating, and zinc plating wastes could be tolerated by the activated sludge process before serious impairment of the quality of effluent occurred. The limits of tolerance are summarized as follows:

Treated Waste Solution	Nitrification		Suspended Solids Affected (p.p.m.)	Sludge Settling Affected (p.p.m.)
	Affected (p.p.m.)	Destroyed (p.p.m.)		
Carburizing	500	2,200	over 2,200	over 2,200
Copper Plating	500	1,200	over 1,200	over 1,200
Zinc Plating	500	1,200	over 1,200	over 1,200

Sodium cyanide, while demonstrating toxicity, was not as destructive as would be expected. Nitrification was depressed but not completely destroyed at 40 p.p.m. of NaCN.

The limit of tolerance for polysulfide was quite high. Nitrification was practically unaffected until 1,000 p.p.m. of the waste was added. None of the wastes, in the amounts added, caused either disintegration of the activated sludge or a change in the settling characteristics of the floc.

The process showed quick recovery from the effect of all of the wastes when added in excessive amounts, i.e., amounts sufficient to impair normal purification activities. Two days was generally sufficient time for the supernatant liquor to return to normal.

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Sewage Works Design

THE DESIGN, OPERATION AND MAINTENANCE OF SEWAGE LIFT STATIONS*

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This paper on the design, operation and maintenance of sewage lift stations deals briefly with the sixteen lift stations that form part of the Greater Winnipeg Sanitary District collection works in Greater Winnipeg, Manitoba, Canada. The section on design has been prepared by D. L. McLean, Superintendent, and the operation and maintenance is discussed by A. T. Puttee, Outside Engineer.

The Design of Sewage Lift Stations

Previous to the operation of the Sanitary District works, the trunk sewers of Winnipeg and its surrounding municipalities emptied into the Red and Assiniboine Rivers (Fig. 1). The intercepting sewer which collects the sewage from these trunks and conveys it to the treatment plant parallels both rivers. This intercepter also receives sewage from trunk sewers across the rivers by pumping through Universal cast iron pipes laid in the river bed. Owing to the flat nature of the country and to construction difficulties, it was impracticable to build the intercepter low enough so that all trunk sewers could deliver into it by gravity. Consequently, pumping stations became necessary at sixteen locations (Fig. 1).

Table 1 gives information relating to these stations.

Of the sixteen lift stations, ten have superstructures and six are entirely below ground. A small weir diverts the dry weather flow and about 2.75 times the dry weather flow during storms to the inlet pipe, which can be shut off or used to control the flow by a standard gate valve. The incoming sewage next passes over riffles to catch any heavy materials sliding along the bottom and then passes around a scroll-case type of channel which delivers the flow to the comminutor. This comminutor or cutting screen cuts and screens the sewage to ¼-inch size. The comminutors are set on adapter plates which provide for larger units being installed in the future, if required. The stand for the gate valve and motor for driving the comminutor are on a floor above ordinary flood level. After passing through the comminutor, at slow speed, the sewage enters a sump. From this sump it is drawn by a vertical, low-lift centrifugal pump which is motor driven and float controlled.

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FIG. 1.

The electrical equipment (550 volt for the motors and 110 volt for the lighting) is specially designed for wet locations and moisture. The underground structures are of reinforced "kalicrete" concrete. The superstructures of ten stations are of brick and are of attractive appearance. The pump piping is flanged cast iron while standard cast iron check and gate valves control the discharge.

Design Period

The machinery installed was for a design period up to 1945 and the pumps and other equipment were designed to lift a sewage flow of 2.75 times the dry weather flow estimated for 1945. The underground structures were designed for 2.75 times the dry weather flow estimated as at 1985. This 1:2.75 ratio of dry weather flow to wet weather flow to be lifted by the stations corresponds with the 1:3 ratio established by the British Royal Commission for Great Britain.

Diversion of Sewage from the Trunk Sewers

As the stations were located at the end of the trunk sewers near their old discharge point into the rivers, small diversion weirs are used to divert the dry weather flow and, in times of storm, 2.75 times the 1945 dry weather flow, to the lift stations from the trunk sewers.

Flood Gates

Calco iron flood gates were installed to hold back the spring flood waters from the rivers. Unless an exceptional rain occurred at high river stage the sewers would fill to some point below the river stage and

TABLE 1.—*Lift Station Equipment*

Stations	Comminutors		Pumps			Motors (H.P.)
	Size (In.)	Motor (H.P.)	No.	Head (Ft.)	Capacity (U. S. G.P.M.)	
Ash	15	2	2	40	2,000	30*
Aubrey	15	2	2	35	2,300	30
Cornish	10	1.5	1	25	850	10*
			1	25	1,400	15*
Jessie	15	2	2	50	1,500	30
River	10	1.5	2	25	1,000	15*
Marion	15	3/4	1	40	1,500	25
			1	40	2,000	30
Rue Despins	10	1.5	2	20	700	7.5*
Syndicate	10	1.5	2	30	650	10*
Boyle	10	1.5	2	30	450	7.5*
Montcalm	25	1.0	2	45	2,500	35.0
Hart	10	1.5	2	45	1,000	20.0*
Munroe	10	1.5	2	25	700	10.0*
Clifton	15	2.0	1	33	500	10.0*
			1	33	1,500	20.0
Metcalfe Place	10	1.5	2	45	2,000	35.0*
Baltimore Rd	10	1.5	2	26	500	7.5*
St. Vital	10	1.5	2	51	500	15.0*

* Starters interlocked.

after a time the lift station pumps would pump this storage down and the gates would not open. In extreme cases, the flood gates would open and the level in the sewers would then be a few inches higher than they would be under free discharge.

Lift Station Structures

The underground structures for the sixteen stations are of reinforced concrete. Due to their proximity to the rivers and to soil conditions, the concrete was designed for water pressure up to elevation 20 and for earth pressure above that elevation. The stations vary in depth (from the ground surface) from 16 to 37 feet, with most stations having roughly a depth of thirty feet, of which some ten feet would be designed for earth pressure and the remaining twenty would be designed for earth pressure plus water pressure.

Some idea of the quantities of concrete and steel used in twelve of these stations may be gathered from Table 2.

TABLE 2.—*Lift Station Concrete Requirements*

Station	D.W.F.—1985 (U. S. g.p.m.)	Concrete (Cu. Yds.)	Reinforcing Steel (Lbs.)
Ash	3,850	220	33,344
Aubrey	2,460	175	27,228
Cornish	820	82	9,269
Jessie	1,720	150	22,407
River	700	100	13,112
Marion	4,330	125	16,906
Rue Despins	472	90	10,212
Syndicate	472	93	7,402
Boyle	333	85	10,273
Montcalm	3,670	205	32,047
Hart	1,000	100	12,574
Munroe	785	100	10,132
Totals	20,612 g.p.m. or 29.68 m.g.d.	1,525 cu. yds.	205,086 pounds or 102.45 tons

The concrete was made from graded gravel aggregate and "kali-crete" cement to give concrete having a minimum compressive strength of 3,000 pounds per sq. in. at 28 days. It was carefully placed and tamped by vibrating tampers. This gave a dense, strong, waterproof concrete.

Connections to Trunk Sewers—Gate Valves and Piping

Connections to the trunk sewers were made with concrete pipes, ten of which were 18 inches in diameter, five were 24 inches in diameter, while one was 36 inches in diameter. Standard gate valves were used to control the inflow while check valves and gate valves were provided on the discharge piping, which was flanged cast iron except at the pumps where two victaulic joints were provided to facilitate removal of the pumps.

Comminutors or Cutting Screens

Chicago comminutors or cutting screens were provided at each station. These machines are driven by small motors located in rooms above ordinary flood level. A gear was provided to reduce the motor speed to 49 r.p.m. for 10-inch machines, 37 r.p.m. for 15-inch machines and 23 r.p.m. for 25-inch machines.

The first setting of these machines gave trouble but this was remedied by providing a scroll type of channel which distributed the flow over more of the screen area. These machines cut and screen material into approximately quarter-inch size. Any heavy gravel, stones or similar materials are caught on riffles above the machines and must be removed by hand.

The stations were designed for 2.75 times the 1945 estimated dry weather flow and adapter plates were provided for future enlargement.

Pumps, Motors and Controls

The capacity of the pumps was based on 2.75 times the estimated dry weather flow for 1945 and the total dynamic head was computed for such flows. Two vertical, low-lift, motor-driven centrifugal pumps were provided for each pumping station and provision was made, where required, for extra pumps for future flows.

These centrifugal pumps are of the single-stage, single-suction, vertical shaft, non-clogging type with horizontal inlet and horizontal discharge. The impellers are of cast iron and of the shrouded type, capable of passing spheres from 2¼-inch to 3⅜-inch diameter (depending on the size of the pump). They were manufactured by the Dominion Engineering Works of Montreal, Canada.

They are driven by vertical, 550 volt motors which are controlled and operated by program mercoid switches operated by a float in the pump sump. These controls enable the sequence of operation of the pumps and levels in the sump to be controlled at will. The program switches were supplied by the Automatic Control Co., St. Paul, Minn.

The pumps were purchased on the basis of efficiency and the following computation may be of interest to show the method used for comparing tenders:

Pumping Station No. 1—2 units required (2,000 g.p.m. at 40 foot head)

$$\text{H.P. required for each unit at 100\% eff.} = \frac{40 \times 2{,}000 \times 8.33}{33{,}000} = 20.3 \text{ H.P.}$$

	Efficiencies, Wire to Water, %	Price Tendered	Actual H.P. Required	Adjusted Price
Bid 1.	62.3	$3,789.89	$\frac{20.3}{0.623} = 32.6$	$3,789 + 1,820 = $5,609
Bid 2.	73.8	3,806.00	$\frac{20.3}{0.738} = 27.5$	3,806 + 0 = 3,806
Bid 3.	69.0	3,765.00	$\frac{20.3}{0.69} = 29.4$	3,765 + 678 = 4,443
Bid 4.	73.0	4,500.00	$\frac{20.3}{0.73} = 27.8$	4,500 + 107 = 4,607

Cost of power taken at $40.00 per H.P. year.
1 Pump assumed to run two thirds of the time.
Capitalized at 7½ per cent.
Diff. between 2 & 1—5.1 HP @ $40.00 × 0.67 = $136.50 ÷ 7½% = $1,820.00
Diff. between 2 & 4—0.3 HP @ $40.00 × 0.67 = 8.05 ÷ 7½% = 107.00
Diff. between 2 & 3—1.9 HP @ $40.00 × 0.67 = 50.90 ÷ 7½% = 678.00

Gland Water

In order to provide clean gland water for the pumps, a water connection with the city water mains was put in at each station. To safeguard against siphoning sewage at this connection during a break in the water mains, a special water tank with an air gap was provided. This was a standard 30-gallon galvanized hot water tank. The water line from the city meter was a half-inch copper line with a gate valve, a pressure reducing valve or water pressure regulator, and a check valve. Where the half-inch pipe entered the boiler, a short piece of ⅜-inch brass pipe projected into the tank (hot water boiler) and to this was brazed 1½ inches of ¾-inch brass pipe with the bottom end closed to form a water seal on the intake pipe. A vacuum relief valve and a sight water gauge were located on the upper portion of the tank. A drain (½-inch) was provided at the bottom of the tank to allow it to be drained and filled with air. This was later supplemented with a small portable air pump to put the air into the tank to form a gap between the incoming water and the water in the bottom of the tank. From the side of the tank near the bottom, a ½-inch line with two needle valves leads to each pump gland so that the quantity of gland water can be regulated at will. The pressure reducer lowers the water pressure from 65 lbs. to 25 lbs. per square inch.

In three stations the size of tank has been increased so that it would be possible to leave the station operating longer periods between inspections and minimize the replenishing of the air gap in the tank.

Pump Sump

These structures, being underground near the river bank and below summer river level, were designed for the ultimate estimated dry weather flow, or that of 1985.

Ten of the sixteen sumps are circular in cross-section, being 6.5 feet in diameter, while the remaining ten are rectangular. The smallest sump has a capacity of 5,000 U. S. gallons while the largest has a capacity of 22,600 U. S. gallons.

The equation for sump design is as follows:

Let x equal the flow into the sump in U. S. g.p.m.
y equal the capacity of the pumps in U. S. g.p.m.
A equal the capacity of the sump in U. S. gallons.
B equal the length of run of the pumps in minutes.
C equal the interval in minutes between pump operations.

Then:

$$A + xB = yB \quad \text{.......... equation 1}$$
$$xC + xB = yB \quad \text{.......... equation 2}$$

By subtracting 1 and 2,

$$xC - A = \text{zero}$$
$$xC = A$$
$$x = \frac{A}{C} \quad \text{.......... equation 3}$$

For example, take a station with an estimated dry weather flow of 3,850 U. S. gallons per minute, an ultimate pump capacity of 10,500 U. S. gallons per minute and a sump capacity of 22,600 gallons:

Using equation 1,

$$22{,}600 + 3{,}850\,B = 10{,}500\,B$$
$$B = 3.4 \text{ minutes}$$

Using equation 2,

$$3{,}850C + 3{,}850 \times 3.4 = 10{,}500 \times 3.4$$
$$C = 5.9 \text{ minutes}$$

For the 1945 design period:

Est. dry weather flow is 1,370 U. S. gals. per min.
Pump capacity 2,000 U. S. gals. per minute,

$$B = 36 \text{ minutes (on)}$$
$$C = 16 \text{ minutes (off)}$$

If pump capacity of 4,000 U. S. gals. per minute is used,

$$B = 8.6 \text{ minutes (on)}$$
$$C = 16 \text{ minutes (off)}$$

The equations give the designer of a lift station the times of pump runs which tell him if the period of run is satisfactory.

Costs

The following contract costs based on twelve of the lift stations may be of interest, though it will be some time until similar low cost labor and material can be secured.

12 Pumping stations	$ 88,478.29
24 Pumps, motors and piping, etc.	35,260.13
12 Comminutors and motors	28,500.00
12 Trunk connections	18,500.00
12 Stations' electrical equipment	15,274.87
Total	$186,013.29

To this should be added the cost of engineering and miscellaneous costs amounting to about ten per cent. This gives an average cost of $17,000 per station.

The power costs for the sixteen pumping stations for the year 1942 amounted to $12,427.09. The cost of operating the sixteen pumping stations and eight comminutor stations for the year 1942 was $39,919.04 and for the twelve stations (above) the cost was $14,066.00.

In the preliminary studies for the Greater Winnipeg sanitary works, a gravity system and a pressure system were compared. However, underground conditions simplified many of the calculations of such a nature on this work, as rock and artesian underground water set definite limits to which gravity works could be installed. As a result, the lift stations were used with a gravity intercepter and give an economical and satisfactory system.

Operation and Maintenance of Sewage Lift Stations

The staff which operates the sixteen lift stations along with eight gravity stations, consists of eight men comprising 3 operators, 4 assistants or helpers, and an engineer.

The stations are located at or near the lower ends of the trunk sewers serving the Greater Winnipeg District. The distance travelled in going from station to station is approximately forty miles. Three trucks are used for transporting men and equipment between stations. Two of the trucks are used as general service trucks and each carries:

1. A portable blower to supply fresh air to the underground structures when necessary.
2. Fresh-air masks with air hose and manifold to connect with the blower when it is necessary for men to work in chambers where the gases cannot be removed by the blowers.
3. A gas testing box containing testers for determining the presence of H_2S, CO and explosive mixtures.
4. Safety harness with ropes attached.
5. Miscellaneous tools, shovels, pails, wrenches, etc., for cleaning out debris and making minor adjustments to the machinery.

The third truck is used as a utility and maintenance truck. It carries heavier tools, such as chain blocks, loading equipment, etc.

The District does not have a machine shop of its own but uses the City of Winnipeg machine shop on the same basis as do the various departments of the City. All the major repairs to comminutors and pumps are made at the City of Winnipeg shops.

The routine of operating the twenty-four stations takes considerable time. Each station is visited every day. Three days per week the routine at each station is as follows:

On arrival at the station the operator must satisfy himself that it is safe to enter the underground chambers. If there is any evidence that the station contains dangerous gases, the operator uses the gas testing apparatus to determine the nature and quantity of the gas. If a dangerous condition is found, fresh air is blown into the station by the portable blower which is carried in the truck. When the station is free from dangerous gases the influent gate is closed and locked and a man wearing a safety belt with rope attached enters the comminutor pit and cleans out any grit or debris that the comminutor machine cannot cut up. He also inspects the cutting edges of the machine and greases the bearings.

The pump room and motor room are also visited and the pumps and motors and electrical control system are inspected. Any necessary adjustments are made.

The seals on the pumps are supplied with clear water from the city water services. To guard against contamination to the city water system, the pipe line to the sewage pump and the water service pipe are separated by compressed air. This is done by having the water service enter the top of a closed tank compressing the air in the bottom of the tank. Further precautions are taken by having a check valve in the water service pipe and also in the pipe to the pump. The water service pipe is fitted with a pressure regulating valve so that the required pressure may be obtained on the pump seal. The tank is fitted with a gauge glass and scale so that the amount of air separating the water in the tank and the water service line can be seen. The operator reads and records the amount of air in the tank each day and recharges the tank when necessary.

The operator records the following at each station:

1. The time visited.
2. The number of the pump or pumps operating.
3. Comminutor serviced and amount of refuse removed from comminutor pit.
4. Amount of air in the water-air tank.
5. The results of gas tests.
6. Adjustments made.
7. Any other work done.

Four days each week, each station is inspected to see that everything is running properly.

The lift stations pump the sewage from a combined system of sewers. That is, the domestic and industrial sewage plus a portion of the surface drainage and storm waters. Therefore, exceptional operating conditions due to the weather must be considered.

From early spring until late autumn, the weather may play havoc with any operational routine. During the spring runoff, when large quantities of grit from the streets are carried into the sewers, it has been found advisable to close down some of the stations to avoid excessive wear on the machinery. During the summer, heavy rains and storms, especially after a prolonged dry period, flush out the sewers and the quantity of solids to be handled by each station is greatly increased. This necessitates extra cleaning and additional inspection and servicing of the comminutor machines. During the winter months, there is no large variation in flow to cause trouble; however, the extreme cold weather often creates problems.

Shut-Downs and Gas Hazards

The pumps being automatically controlled and visited only daily, the overload controls on all motors are set to give maximum protection, not only to the motors but also to the driven machinery. Shutdowns due to overloads occur especially during heavy rains and thunder storms.

When a station has been in continuous operation for some time, the sewage is fresh and very little H_2S gas is found. However, gasoline and cleaning fluids and other dangerous mixtures sometimes do get into the sewers in spite of all the laws and controls imposed to stop them. Therefore, the operator must be on guard at all times to detect a dangerous condition.

When a station has been closed down for some time, some H_2S gas is usually liberated when the station is put into operation again.

Maintenance of Machinery

The screening machinery is naturally the first to be discussed in the maintenance of the lift station equipment. If the screening machinery is not working efficiently, the pumps will clog frequently and the overall efficiency approaches zero. The screening of the sewage is done by comminutor machines in which the screening is done by a slotted cylinder revolving in the sewage and the cutting is done by stellite teeth inserted on the cylinder and meshing with stellite-edged teeth on a comb held stationary alongside the cylinder.

Soon after the machines were put into operation, it was found that a great deal of maintenance and many improvements would be necessary to make the machines operate successfully. The machines were repaired at the city machine shop and alterations were made in an effort to improve their design. Some of the improvements were:

1. Stellite-edged shear bars were inserted on the cylinder so that all cutting edges are stellite.
2. The bars between the slots of the machine were built up by brazing with bronze so that there was no space for strings to slip past the teeth.
3. Extra combs were made for each machine, so that combs could be changed without removing the machine from the pit.
4. Clearances on the cutting edges were reduced. Cutting edges were set with a minimum clearance of 0.001 inch and a maximum of 0.005 inch.
5. Stainless steel is used for the body of combs and shear bars.
6. The lower half of the cylinder was replaced by a new section.

Besides the changes made to the machine itself, the position of the machine in relation to the flow of sewage was changed. The shape of the flow channel was also changed.

The essential factors for successful operation of comminutor machines are, first, frequent inspection of the cutting edges and, second, the maintenance of clearances between the cutting edges to less than a maximum of 0.010 inch. For continuous operation of comminutor machines, one spare machine is necessary for every four machines operating.

The maintenance of the vertical sewage pumps has caused very little trouble. The clearance on the wearing rings is inspected and adjusted periodically and new wearing rings installed when necessary. The packing glands must be kept a little tighter than is required for the most efficient operation of the pumps due to the danger of the impeller becoming unbalanced by something catching on one side when the operator is not at the station.

The maintenance of electrical equipment must necessarily be mainly preventive maintenance. A regular inspection of starter boxes, circuit breakers and switches is maintained. Insulation breakdown tests are made of motors and feeders in damp locations. In lubricating motor bearings, the tendency is to over-lubricate. This must be guarded against as the grease will get into the motor windings and cause insulation deterioration and, eventually, complete failure.

The switch controlling the operation of the pumps is activated by a float in the pump sump. The control switch is of the mercury tube type and has been redesigned, eliminating two of the four mercury tubes. The simplified switch is operating satisfactorily and has thus eliminated a considerable source of trouble.

The lift station structures are built of reinforced "kalicrete concrete." No deterioration of the concrete has been found to date.

The sixteen lift stations of the Winnipeg system are all very similar in general design. However, due to the variations in the nature of the sewage, the amount of sewage and all the other variations that are found in any sewage system covering an entire city, there are many operating and maintenance problems that are characteristic of each individual station.

The most difficult station to operate and maintain is one which handles the sewage from two large abattoirs, four small abattoirs and an oil refinery along with other industries. The flow to this station varies between four and seven million gallons per day. Large amounts of animal offal, pig toenails and paunch manure are carried in the flow. The 25-inch comminutor at the station cannot cut up this material quickly enough and much of it must be hauled out of the pit for disposal. The District is working with the packing companies to have most of this material removed before it reaches the sewers.

The pump sump at this station is cylindrical in shape, 6.5 ft. in diameter and 96 ft. long. It was found that the solid materials settled out of the sewage and filled the sump to a depth of two to three feet. A wall three feet high was built along the center line of the sump so that when the pumps had lowered the elevation of the sewage in the sump below the top of the wall, the sewage flowed around the wall. The velocity of the sewage was thus increased sufficiently to keep the sump clean.

THE OPERATOR'S CORNER

WOMEN OPERATORS?

Polish up your manners, operators—here come the ladies! Not content with only the right to vote, crowd the barber shops and wear trousers, they now show their versatility in the assumption of occupations restricted heretofore to the male of the species by donning the dungarees and duties of the sewage works operator. And, if we are to believe some of the harassed superintendents who are trying to get along these days, they may be outdoing Joan of Arc in coming to the rescue in the nick of time.

In prewar days, it was something of a novelty to hear of feminine employees, even in sewage works laboratories. Lately, many plants are served by women in the capacity of chemist or laboratory technician, and in mighty fine fashion, as we can testify from personal experience. We believe it is something of an innovation, however, for a young lady to be employed as a shift operator, as has been done at the Decatur (Illinois) Sanitary District by Superintendent W. D. Hatfield, and would be interested to learn if women operators have been employed elsewhere.

At Decatur, the "operatoress" has been assigned light duties such as collecting samples, reading meters, and changing charts and is being taught how to inspect and lubricate equipment. There is no reason why women cannot perform such functions, and others, very well. With "good housekeeping" one of the cardinal points in proper sewage works operation, many of the lighter chores incident thereto might well be accomplished by feminine personnel. And they should be able to teach the men a thing or two about it!

What a change will be wrought if the Decatur practice forecasts a general trend! The plant designer will be sadly remiss if he does not provide a powder room in the Administration Building; chic uniforms in pastel shades may replace the practical coverall for operators of both sexes; the language used to safety valve one's feelings when mishaps occur will be curbed to more proper but less picturesque terms; curtains, drapes, rugs and other adornments may render a homelike atmosphere to the pump room and screen house. The day may even come when the *Journal* will feature a fashion section and society column!

Welcome girls, your assistance is appreciated. And the job of the sewage works superintendent becomes more interesting than ever!

W. H. W.

A UNIQUE METHOD OF GAS COLLECTION AND UTILIZATION *

By J. P. Burden

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Before discussing the San Angelo gas collecting system, it would be wise to review briefly sewage sludge digestion and gas utilization. The removal of suspended matters from sewage, whether by screens, sedimentation or as scum, is but the first step in disposal, for the solids still remain to be disposed of in some way. The method of digestion of fresh sludge now practiced in most modern plants is a biochemical breaking down of the organic matter, whereby much of it takes a gaseous or liquid form, and the sludge is rendered drainable and less offensive.

Digestion is secured by retention of the sewage sludge in tanks of such size and form and under such conditions as will secure continuous and maximum digestion in the minimum time, and with the least operating difficulty. The gas produced by digestion can be and in an increasing number of plants is being used for heat and power.

The separate sludge digestion tank is replacing other types of digestion units; however, the Imhoff tank still has its place in sewage treatment. To secure well digested sludge requires detention in a tank for weeks or months, and the size of the tank must be sufficient to hold the amount of sewage solids accumulating during the digestion period, together with increments of fresh sludge (generally added daily), and retained until well digested. In addition, the tank must hold a considerable amount of dilution water. Anything that will reduce the duration of digestion makes possible the reduction of the size of the tank. Such aids to digestion are heat, regular and frequent addition of fresh sludge and immediate seeding by digesting sludge.

Gas liberated during digestion is generally collected by means of one or more domes or small inverted tanks in the roof, from which a pipe leads it to the boiler where the water is heated or to the gas engine which it operates. Gas compressors are sometimes used for increasing the pressure for storage in gas tanks.

The gas given off during digestion is generally about 65 per cent methane, which is explosive when mixed with between 8 and 19 times its volume of air; explosive mixtures of gas and air in the top of tanks should be guarded against. The gas collected from the tank should, therefore, be handled with care. Pressure relief valves and flame traps are essential parts of the gas system, and they must be used to insure safety.

Under regular operating conditions the volume of the gas delivered is approximately 16,000 cubic feet per ton of equivalent dry solids per day. Experience has shown that about one cubic foot per day per per-

* Presented at 26th Texas Water Works and Sewerage Short School, A. & M. College, Jan. 31–Feb. 3, 1944.

son can be expected from the connected population contributing domestic sewage, and a higher yield may be expected if industrial waste or if garbage is treated at the sewage plant.

Sewage gas does not vary greatly in composition from plant to plant. The gas is composed of methane, carbon dioxide, and small amounts of hydrogen, nitrogen and hydrogen sulfide. If the hydrogen sulfide content is higher than 5 grains per 100 cubic feet, it is essential to treat the gas to reduce the H_2S or it will cause pitting of the gas engine, clogging of piston rings or form sludge in the crank case oil. The usual way to remove the H_2S is to pass it through iron oxide, generally supplied as iron shavings.

Gas formed in digestion tanks has a B.T.U. value of about 600 to 700. To produce 1 horsepower hour would require about 17 cu. ft. Any community with a connected load of 10,000 can well consider the utilization of its gas for power. This implies an available gas yield of 10,000 cu. ft. of gas per day, which is equal to the development of 18–20 horsepower. In many cases this would be sufficient for both pumping and power requirements.

Sewage gas engines are now in operation varying from small 20 h.p. units up to 1,000 h.p. installations in a single unit. Gas engines are used by direct connection to pumps or to blowers and for driving generators. They are notably dependable. Granted an uninterrupted supply of water, fuel and oil, they are as dependable as motors, and they operate at a remarkably low annual maintenance cost.

The San Angelo sewage treatment plant consists of three Imhoff tanks with gas collection facilities, trickling filter, secondary settling, broad irrigation and sludge drying beds. The connected population is estimated at 32,000 with a daily flow of sewage of a little less than 1.6 million gallons. The sewage from the Goodfellow Field Flying School is treated at the plant. The sewage is a rather concentrated domestic sewage since the per capita flow is below normal.

The San Angelo plant varies from the ordinary Imhoff tank-sprinkling filter system in two ways: first, the gas vents of the Imhoff tanks are covered and the gas is collected and conserved as fuel; second, the broad irrigation system is arranged and functions so that the sludge is pumped and spread over farm land with the plant effluent.

The gas vent covers and the gas collecting system are simple and effective. The gas vent cover is a flat concrete slab. The bottom of the slab cover is three inches below the normal water line of the tank. Each of the covers has four 3-inch pipes spaced at regular intervals and well distributed over the cover area. The 3-inch pipes extend to the bottom of the slab, and they rise to an elevation of four feet above the bottom of the slab to where they are connected by pipe crosses into a header pipe that carries the gas to the main gas line. Each cover has a 24-inch machined and bolted manhole ring and cover. Also, each gas vent cover has a pressure relief device, which consists of a 6-inch piece of wrought iron pipe extending 24 inches below the bottom of the gas vent cover slab, and it rises to an elevation of four feet above the bottom of the slab cover. Then each side of the tank has a 12-inch pipe, with a blank flange, through the tank wall at an elevation just below the bottom of the slab. The purpose of this pipe is to permit the withdrawal of scum.

These four items, consisting of a flat concrete slab, four 3-inch pipes, one 6-inch pipe, and one 12-inch pipe, make up the complete gas collecting device for each side of the tank.

The gas pipes from the three Imhoff tanks are connected into one 2-inch pipe. On this main gas line is a drip trap for collecting as much moisture as possible. From the drip trap the gas passes into a scrubber for the purpose of reducing the hydrogen sulfide to a safe minimum before it goes to the gas engine. The gas then goes through another drip trap, regulator and flame trap and then into the engine. On the main gas line is a relief valve and a waste gas burner to dispose of any gas that is not required by the engine.

The gas engine is connected directly to a 6-inch sludge pump. The pump pit receives the effluent from the three Imhoff tanks. That part of the overflow from the pump pit which is not disposed of by broad irrigation goes into the dosing tank and sprinkling filter. The pump may also be directly connected to either of the Imhoff tank sludge withdrawal lines by the use of valves. On each sludge line is a water connection and a valve that permits the dilution of the sludge to facilitate pumping.

It will be recalled that the bottom of the gas vent cover was placed three inches below the normal water elevation of the tank. This was done so that there would be no space below the cover where scum could dry out. The usual amount of scum does form but since it is below the water line, and there is a constant movement of the scum caused by the escaping gas, the scum seldom gets very thick or dry. On a few occasions, it has been advisable to thin the scum. This is done by removing the pipe cap in the top of the header cross and applying water pressure at each of the 3-inch pipes.

Because the scum is always moist, it decomposes or digests so rapidly that it is very seldom necessary or advisable to draw off any scum. The tanks have gone for several years at a time without scum being drawn and it does not appear to be getting any thicker or heavier.

The function of the manhole is to permit the removal of the construction forms and allow entrance to the digestion compartment, if necessary. The ring and cover of the manhole is machined and bolted.

The safety device is a very important and necessary part of the gas collector. Stoppages of the gas lines do occur, and without some kind of a relief valve the gas pressure might become great enough to cause the walls or top to fail. Stoppage of the gas lines has occurred when the scum in the top of the tank would freeze; also foam and other objects have entered the gas lines and have caused a complete stoppage of the gas flow. The 6-inch open pipe makes a very simple safety device. It is inexpensive and it is certain to function just as soon as the gas pressure is equal to the pressure of the column of water.

The 12-inch pipe with the blank flange in the side of the tank is merely a precautionary measure, just in case it is ever desirable or necessary to draw scum.

The fact that the gas vents of an Imhoff tank are covered will not keep it from foaming. The first thing that will happen under such circumstances is that the foam will belch up and clog the gas lines. If the stoppage is not discovered, the foam will soon begin to boil out the top of the 6-inch safety pipe. As soon as the foaming condition is detected, the gas valve on this tank is closed, a plug is removed and a 3-inch pipe placed in the gas header, which pipe is run to the nearest sludge bed. With the aid of the gas pressure, the foam will continue to be pushed out of the 3-inch pipes. If the foaming is bad, it will be very thin and it will distribute itself over the sludge bed. As the foaming slows up and the tank begins to return to normal, the foam will become so thick that the plant operator must spread it uniformly over the sludge bed. It has always been our practice to take the foaming tank out of service when possible. However, on occasions the tanks have been left in service and the results have been satisfactory during the foaming period, since none of the foam could get into the flow chamber of the tank. The foam dries rapidly in the sludge beds. It is disposed of in the same manner as the dried sludge.

The gas engine is of 25 h.p. at 1,100 r.p.m. It is a 4-cylinder, valve-in-head industrial engine manufactured by Climax. The gas engine is directly connected to a 6-inch, centrifugal, open impeller sludge pump. The capacity of the pump at 1,100 r.p.m. is 1,400 g.p.m. against the maximum lift of 42 feet. The pump will not take all of the flow during the peak. However, any sewage that is not disposed of by broad irrigation overflows into the dosing tank and on through the trickling filter and final tank. The gas engine has been in service two years. The results so far have been very satisfactory, and maintenance costs have been very low. The engine requires no attention except that the oil and cooling water must be attended. The engine is allowed to run through the night without an attendant. The engine is equipped with a float control which slows the engine when the water in the pump pit begins to lower.

In addition to furnishing fuel for the gas engine, the tanks supply domestic gas service for three residences which are occupied by workers at the sewage plant and farm. The remainder of the gas goes through a waste gas burner or to open furnaces where the screenings and skimmings are disposed of by incineration.

From several years of operation of the Imhoff tanks with the gas collecting system the following conclusions are reached:

1. There is no reduction in the efficiency of the Imhoff tank because of the covers on the gas vents.
2. The covered gas vents make the operation of the tank easier, since there is no scum to cause odors or to require other control.

3. The covers on the gas vents provide a simple and effective control of foaming.
4. Screenings and skimmings are effectively and completely burned by the waste gas.
5. The fuel that is conserved by collecting the gas goes far toward reducing the operating cost of the sewage treatment plant.
6. No objectional features have been experienced by reason of the covered vents.

MAINTENANCE OF ELECTRICAL EQUIPMENT IN SEWAGE TREATMENT PLANTS *

By L. F. Woolston

Engineer, St. Louis Office, General Electric Company

Statistics prove that the health record of any community is very definitely dependent upon an adequate supply of pure water as well as an effective means of sewage disposal. It is self-evident, therefore, that these two services must not be allowed to fail. Successful operation, in turn, depends to a large extent on a carefully planned maintenance program by the management.

A planned maintenance program is economically sound and pays big dividends whether it be a public or privately operated enterprise, or even one's own personally owned automobile. In the present war emergency, the subject is of even greater importance and, no doubt, this is the reason why this topic has been placed on your program.

Our country's three critical materials are steel, copper and aluminum and it so happens that these are just the metals from which motors and electrical apparatus are made. It is apparent, therefore, that any piece of electrical equipment which is wrecked or burned out due to negligence or carelessness or ignorance is just as much of an aid to the enemy as if the damage had been deliberately planned by Jap or Nazi agents. Materials, to say nothing of man hours, which must be utilized in restoring damaged machines could be used to much better advantage on new equipment for our armed forces.

What can an operator do to prevent excessive failures and repair costs? The first answer is for him to know his apparatus and the conditions under which it is operating. He can then ask himself the following questions:

Am I using a standard general purpose, open type motor in a place that is subject to continuous dampness, flood waters or other adverse atmospheric conditions? If so, why should I not take the matter up with the manufacturer and explain my conditions to him and get his recommendations? Perhaps he will tell me that I should have some extra insulation treatment to take care of these particular conditions,

* Presented at Illinois Sewage Works Operators Conference, Springfield, Nov. 16–17, 1943.

or he might even suggest that a totally enclosed, fan-cooled motor be used in place of the open type, or perhaps a splash-proof or drip-proof motor might be better suited to that particular application.

Is my motor overloaded? If so, am I not causing excess heating in the windings which in turn will bake out the insulation causing it to become dry and brittle and eventually flake off and cause a failure?

Do I allow my motors to start and stop too frequently? If so, I must realize that the starting current of a motor may be several times its full load current and these starting currents will store up heat in the windings.

Have I checked my starting equipment to see if it is the correct device to use with the motor to which it is connected? Do I know that its overload relays or temperature elements are properly selected for the motor? Do I know that in case of trouble the starting and protective device will trip off the motor before it has had a chance to reach a dangerous temperature? If I know that my protective device has been correctly applied and in proper working condition, then I need not worry about the excessive number of starts or whether I am carrying a dangerous overload, because my protection will give me suitable warning in plenty of time.

If I am using belts, do I know that my belt tension is within safe limits? An excessive pull on the motor bearings may mean that the required film of oil would be squeezed out due to this pressure and the bearing will not only run hot but will wear itself to the point that the rotor can be pulled over and rub the stator laminations, which, if not caught in time, would result in a complete wrecking of the motor itself.

Do I inspect my bearings regularly and do I keep them properly lubricated? When I put oil in the oil wells do I have my mind on what I am doing or do I simply pour it in carelessly and frequently flood my motors with oil?

Do I follow the manufacturer's instructions in adding grease to the ball bearings?

Do I make regular inspections of all my equipment to make sure that no one has left any boards or covers or canvas or rags or tools, etc., that might interfere with the ventilation or be jammed into the rotating parts?

The operator, of course, must be concerned not only with the motors and their controllers but must see that all of the electrical system, from the point where the power is furnished by the utility company to the remotest lamp, is in no wise neglected.

Where the power company brings their line to your wires or cables, some form of disconnecting device is required. This device is most important. It may take the form of outdoor fused cutouts either of the dry or oil immersed type; a fused air break disconnecting switch; an oil circuit breaker; or, if in new installations, the breakers may be of the oil-less type, such as a Magne-blast. It is not only necessary to see that this device has the proper voltage and current carrying rating, but most important of all is the interrupting capacity to take care of any fault and successfully open the circuit on the amount of fault current which the power company can supply to it. It goes without saying that an interrupting device with a rating of 15,000 kva should not be used when the power company could supply as much as 25,000 kva or greater at the point of failure.

The main points to look out for in protecting devices are to make sure that the contacts are in good condition and have the proper amount of pressure; that they are kept clean and not corroded or oxidized; that their operating devices are in free and good working condition so that they will trip or blow in case of a fault; that the insulators are kept wiped clean to prevent flashover to ground. Experience has shown that silver to silver contacts, in general, give the best results.

Oil which is used either in oil circuit breakers or transformers or in oil filled cutouts, should be frequently examined to make sure that it is clean and has maintained its dielectric strength. Oil which shows a dielectric strength of not less than 22,000 volts when tested between the standard 1-inch diameter flat discs placed $\frac{1}{10}$ of an inch apart is considered satisfactory for use. Oil in perfect condition will withstand 30,000 volts or more under the above test conditions. Oil which does not test up to the required strength can generally be filtered and brought back to at least 22,000 volts, but it is usually not economical to filter oil in very small quantities as the cost of the labor and setting up the apparatus would more than offset the price of new oil.

We cannot go into detail and cover the maintenance of all of the individual devices which you may find in your sewage plant, but the following general advice may be used to advantage:

1. Keep all electrical devices clean.
2. Keep moving parts properly lubricated.
3. Keep up a regular inspection and maintenance schedule.
4. At all times know the condition of your apparatus.
5. Correct any indication of weakness before further trouble develops.

This subject of maintenance of electrical equipment has been considered of such importance that the leading manufacturers have recently published special bulletins containing instructions regarding maintenance of the various devices which they manufacture. These instructions are available to you without charge if you will write to the nearest office of the manufacturer and give him the name plate rating of the equipment for which you desire information.

Discussion

Mr. Larson: You spoke of going up on the pole and wiping off those insulators; aren't you playing with fire?

Mr. Woolston: Yes. You have to make arrangements with the power company and it would be better to have their man do that. The only idea that I wanted to convey was that it should be watched but I do not advocate any of you coming in that close contact with electricity. A lot of people have the idea that as long as they do not touch a wire they are entirely safe. Remember that high voltage can jump through air space the same as lightning does.

Mr. Getz: Is it not good judgment to consider it the duty of the power company to maintain equipment to the distribution panel inside the plant rather than the duty of the operator?

Mr. Woolston: The power company is usually glad to take care of that part of the equipment.

Mr. Sperry: One of the special problems is hydrogen sulfide. While the gas is not there in toxic form, it is enough to affect the copper parts. Are there any suggestions you have that might lend further light on that?

Mr. Woolston: A lot of our modern contacts on disconnecting switches have a thin coating of silver and, while silver oxide is not a good conductor, it does not take a lot of heat to dispel it. If you have a good silver to silver contact with plenty of pressure, excess heating will not take place.

Mr. Watterson: Is it possible to take out the plug and grease a ball bearing motor while it is running and not get in an excessive amount of grease?

Mr. Woolston: Yes, take out the pressure relief plug to prevent that very thing, otherwise it is possible to put too much grease in ball bearings and burn them out. Do not over-grease.

Mr. Spiess: Vertical motors are now commonly used, are they not? How do you grease them?

Mr. Woolston: There are a lot of vertical motors used on pumps and they present a little different problem. Some of these vertical motors are operated outdoors and have to be protected with hoods. Greasing them may require special instructions which the manufacturer will gladly give you.

Question: Would you care to give us some grades of grease to use in these ball bearings?

Mr. Woolston: I don't like to advertise, but practically all the well-known oil companies have a good grease and the General Electric Co. also has a good grease, which you can get right here in Springfield.

Mr. Watterson: What do you recommend be used for washing the windings?

Mr. Woolston: Pure gasoline. Do not use any fancy products—you can also use carbon tetrachloride. The oil companies have a cleaning fluid which is safe to use to wash off the windings. Then put them in an oven and bake them out and put on one or two coats of insulating varnish. In our shop we then add one or two coats of our 1201 red Glyptal as a finish. This will prolong the life of the windings.

Mr. Kraus: You said it was inadvisable to apply the cleaning fluid to transformers with a spray; does that apply to generators?

Mr. Woolston: If you use clean transil oil you can spray transformers all you want. If you spray with a cleaning liquid you are liable to put a lot in a little pocket or some place where you couldn't get it all out, and we wouldn't like to leave cleaning fluid too long on the windings. In the case of a generator, the windings may be sprayed with a cleaning fluid but it should be done with caution and so as not to allow the fluid to stay on the insulation.

Question: Even on a motor winding?

Mr. Woolston: There isn't as much danger on motor windings but I still recommend caution when using cleaning fluids.

Mr. Kraus: In your shop you don't spray with a cleaning fluid?

Mr. Woolston: Yes, in some cases we do but for the inexperienced it would be safer if you wiped or brushed off that equipment.

Mr. Larson: I should like to enlarge on what Sperry said about hydrogen sulfide, which I think is our worst enemy around a sewage plant. We notice it particularly in the braided copper cables that connect with our circuit cables. I was wondering if aluminum could be used for that purpose.

Mr. Woolston: Aluminum could be used. Aluminum is not as good an electrical conductor as copper but aluminum has been used on transmission lines. Power companies use aluminum because it is lighter in weight and they don't have to have as heavy steel poles.

Mr. Larson: Our other enemy, it seems like, is the mud daubers. There is no way to keep ahead of them to keep them cleaned out.

Mr. Woolston: The only thing I can think of is to put a wire screen around the motors.

Mr. Watterson: I read in the last issue of *Popular Mechanics* that if a few moth balls were laid in the switchbox it would keep them out.

THE DAILY LOG *

April 1—What a day! The Board of Trustees ordered us to take a two-month instead of a two-week vacation this year! Six young, husky laborers came out to ask for work! A committee of taxpayers called on us to request that the salaries of all plant employees be increased 50 per cent! The Ration Board insisted that we take twice as much gasoline and a certificate to buy a new set of tires!

APRIL FOOL!

April 7—Laboratory assistant ill so spent most of the day on analytical work. Surprising how awkward one can become in laboratory technique after having been unused to it for some time.

April 12—More illness. Our stenographer-clerk entered the hospital this morning.

We did **not** take over the typewriter!

April 14—Ordered two new pairs of packing gland stud bolts for the sewage pumps. (Psst! The local machine shop found a couple of scraps of stainless steel from which to make them.)

* Based on the 1942 records (augmented) of the Urbana-Champaign (Illinois) Sanitary District.

April 16—Power mower out for the first time of the season.

The usual spring clean-up and paint-up campaign underway. Having all tile roofs and downspouts repaired and painting all outdoor metal at structures and equipment. Using up the last of our stock of good quality aluminum paint.

April 19—Addressed the Illinois Sewage Treatment Short Course on "Natural Purification in Streams," a topic which has always been most fascinating to us.

Operators attending the Short Course out for an inspection trip in the p.m. Many good questions!

April 21—Removed, by manual labor, 10.5 cubic yards of grit from the screen chamber. Our so-called separate sanitary sewage carries approximately 0.5 cu. ft. of grit per million gallons—not much, but enough to give trouble at sludge piping if permitted to pass into the Imhoff tanks.

May 2—Refrigerator-incubator down. Bad news in that the unit must be returned to the factory for a rebuilt exchange unit.

May 7—Whoever started the rumor that lightning does not strike in the same place had better revise his opinion. The secondary clarifier cut out during the night because of lightning—a common occurrence at this plant. The damage was slight but somewhat difficult to locate.

Heavy rains have brought the flow up to 8 m.g.d., more than twice the dry weather rate. Ten-inch line in the campus area giving trouble, apparently due to a grit accumulation.

May 8—Crew at work cleaning 600 feet of sewer found to be surcharged yesterday. The grit accumulation was as much as half the diameter of the sewer in one place and appeared to consist almost entirely of fine coal and cinders.

Cleaning the sewer was not difficult but we do not consider the job finished until the source of the grit is located and its entry to the sewer stopped. Our first suspicion is a surface water source from a part of the campus in which there are several cinder drives. Took up the matter with University officials and requested an investigation.

May 11—Heavy rains continue, flooding the plant with sewage and the office with complaints. Most of the latter were referred to the city street departments since the District has jurisdiction only over the intercepting sewers.

May 15—Back from a trip to Baltimore to attend a very interesting meeting of the Maryland-Delaware Water and Sewerage Association.

May 16—A cloudburst about midnight last night, falling on soil already saturated from past rainfall, caused a 6.6-foot rise in the outlet stream in 12 hours. This rapid rise to flood stage precipitated intense activity in the removal of electric motors and other equipment in the lower parts of the plant most subject to inundation. As attention to the last detail was completed, a check of the stream gauge revealed that the crest had been reached—at an elevation just six inches below the floor of the secondary sludge pumping station!

One precaution taken which may be of interest was the caulking with asphalt roofing cement of all exposed ends of underground electrical conduits to prevent entry of water into them. The value of this precaution was demonstrated during a previous flood when such water caused insulation damage that gave trouble for months afterward.

May 17—More rain and more trouble! After falling a foot from yesterday's crest, the stream (now a raging torrent flowing 1500 c.f.s.) rose again to lap at the floor of the pumping station and to approach to within a foot of the top of the Imhoff tank walls.

The most disconcerting development was, however, the collapse of the stream bank under the weight of a large tree. With about 3,000 feet of stream bank available, this had to happen directly at the outlet of the 12-inch storm drain serving the plant property, causing the runoff from the night rainfall to flood the property to such depth that the water ran over the walls and into the Imhoff tanks. No serious damage was caused, although a 2-inch greater depth of water would have converted the sewage pump dry well into a dandy swimming pool.

Upon arrival home at a late hour, we were interested, to say the least, to read in the newspaper that floods were general throughout central Illinois and that the local National Guard unit had been dispatched to Peoria for emergency duty. Their assignment? **To protect the sewage works of the Peoria Sanitary District from flood damage!** About ten of them could have been utilized to good advantage for the same purpose right here!

May 20—Saline Ditch stage down to 4.5 feet. Restored final sedimentation tank and sludge pumping station to operation. Flood threat seems to have abated.

May 24—Removing the tree which caused the stream bank to collapse at the outlet of the storm sewer. About 90 feet of rip-rap wall 15 feet high will be required to protect the remaining bank and a row of pine trees along the top. Estimated 80 tons of broken concrete to be required and placed an order for same.

May 26—Here we go again! Our stenographer gave notice she was leaving to join her husband who is stationed at an army post. This make the fifth time in three years that the position has been vacated.

May 31—Official weather reports show 11.20 inches of rainfall in May, the second highest in history. Only in May, 1902, when 11.73 inches of rain was recorded, has this mark been exceeded.

June 9—Reversed the direction of flow through the Imhoff tanks, a customary semi-annual procedure. Soundings throughout the length of the tanks show that there is no appreciable "piling up" of solids at the inlet end but there is a distinct difference between the character of solids at the inlet and outlet. Reversal of flow also results in equalizing the gas vent scum accumulation which is always heavier at the inlet end.

June 11—Check valve on No. 2 sewage pump giving trouble. The repair involved only the placing of three small bushings to make up for wear at the hinge and disc bolt but it required seven hours to accomplish.

The usual "beating of the bushes" to round up enough extra labor to begin cleaning sludge beds tomorrow.

June 22—Preparing to resand the north row of nine sludge beds. The samples of local bank-run sand which have been submitted have been found to contain far more clay than that used in previous years so it has been decided to purchase washed river sand which must be shipped in.

Placed order for 225 tons of washed sand at $1.96 per ton delivered. The local sand used heretofore cost about $1.00 per ton.

June 30—Finds us in an unusual position in regard to sludge disposal. Victory gardeners have taken every bit of the old sludge, some of which was three years old. The only sludge now on the stock pile is that which has been removed from the drying beds this spring and we are giving it only to users who wish to apply it to flower beds, shrubbery and for mixing with soil in new lawns.

Did someone say "War is queer"? Shades of Sherman!

July 6—Profiting by the adage "don't wait until it rains to fix the roof," we are having the Administration Building heating system thoroughly cleaned and overhauled. The 20-year old coal-fired boiler is becoming rather decrepit and required considerable attention at the grates and flues. It must last for the duration when replacement by a modern gas-fired unit is planned.

July 7—The Board of Trustees passed an annual appropriation ordinance calling for $67,450 for the current year, which is interesting only because it earmarks $40,000 of funds on hand to "construction of new units." With plans and specifications already complete for a new mechanically cleaned screen, separate sedimentation and digestion tanks and modernizing of the obsolete final sedimentation tank, the above construction account is now large enough to enable the work to be financed by regular tax levies. In other words, no bond issue will be necessary!

Even the taxpayer is pleased with this sort of postwar planning.

July 22—Saline Ditch at minimum stage, permitting work to be started on rip-rapping of stream bank damaged by flood last May. This has assumed the proportions of a major project for our limited personnel.

July 27—Made out about 6 feet of application forms for a permit to purchase 2250 gallons of MC–2 cut-back asphalt for treating the plant roadways. Have been told it takes two to three months for these to be processed.

Oh well, we tried anyhow.

July 31—Mailing out the 1942–43 Annual Report. It is hoped that the report will be of as much interest and value to the plant superintendents who will receive it as we derive from similar reports regarding their plants.

August 2—Will wonders never cease? The morning mail included the permit to purchase the road surfacing asphalt for which we made application only six days ago.

Placed an order and are now advised that delivery cannot be expected for at least 60 days. If it comes later than that we shall have to store it for application next summer!

August 5—This is a very bad season for evergreens in this region, our rather elaborate planting being severely infested with bagworms.

We bagged big, black bagworms by the bushel, then blasted the bushes with bug-killer!

FIG. 1.—View during the 1939 flood, similar conditions being narrowly averted in 1943. Note floating scum at Imhoff tanks (confined by fence) in foreground. Sludge beds under water at upper right.

FIG. 2.—Inundated final sedimentation tank during the 1939 flood.

August 6—Bad news in the form of notice by the young lady who has served as laboratory technician for the past 18 months that she is resigning in order to complete her University work next semester. A home economics student, this girl has done very well in the laboratory, her work being accurate and dependable while the laboratory was kept as neat as a kitchen.

August 11—Patching bad places in black-top roadway in preparation for resurfacing with asphalt and stone chips—if and when we get the asphalt.

August 19—Replaced starter for screenings grinder. Life of the old switch was only 8 years due to the damp atmosphere and generally hard service imposed.

August 20—Inspected the new manhole in the District intercepter at which the new Sanitary Engineering Laboratory at the University will take raw sewage and return the end-products of the research work conducted there.

What a beating that small fraction of our raw material is going to take!

August 25—The sludge bed cleaning crew today shattered all previous records for this plant when they removed 146 cubic yards from eight drying beds (each 25 by 100 feet) in 7.5 hours. This cleaning of the beds has been exceptional throughout, only 18.5 hours having been required to clean 16 beds, despite very hot weather. The crew comprised five men and only one truck was used.

CENTRIFUGAL PUMP MAINTENANCE AND REPAIR *

By A. Nelson

Principal Office Engineer, American Well Works, Inc., Aurora, Illinois

Sewage and sludge pumps are generally divided into two classes: centrifugal and plunger types, of which only the centrifugal are discussed here. All of these handle gritty, trashy, greasy materials and are subject to serious wear from abrasion, corrosion, vibration and misalignment. The characteristics of the material being what they are, it is imperative that the equipment be maintained in a clean condition. Cleanliness is conducive to better care and longer life.

Pumps are the backbone of the sewage treatment plant. Nothing will cripple the plant more quickly than a breakdown of pumping equipment. Complete understanding of their construction and function, periodic inspection and repair are essential to avoid these breakdowns. No pump improperly treated can be expected to do an effective and economical job of pumping. Pumps deserve and must get regular and scheduled attention.

Complete information for each individual type and make of pump cannot be thoroughly covered here. Therefore, general information and discussion on points causing operation difficulties will be stressed.

It is recommended that you maintain a permanent ''Operator's Data'' record of each unit, including equipment specifications, parts, drawings and operating instructions. These data can be obtained by writing the manufacturer, giving him complete name plate data and description of the equipment.

No attempt will be made to cover the maintenance of the prime movers, but its importance must not be overlooked, for without a prime mover the impelling units are useless. Here again it is recommended that the manufacturer be called upon to give you complete instructions.

* Presented at Illinois Sewage Works Operators Conference, Springfield, Nov. 16–17, 1943.

Maintenance of Equipment

A sound maintenance program for pumps and pertinent accessories should be developed and a regular inspection schedule adopted based on actual operating experience. First set up the ''Operator's Data'' file and then maintain a record of inspection so that the uncertainties of memory are eliminated. To insure the best operation of your pumps, make systematic inspections at least once each week. This does not mean that you are to take the pump apart, but it should enable you to perform routine lubricating schedules and keep accurate tab on its operation:

1. Be sure bearings do not overheat from over or under-lubrication.
2. Be sure the motor comes up to speed quickly and maintains constant speed.
3. Be sure control equipment is functioning properly, is clean and contacts are in good condition.
4. Check operation of pump to be sure it is running smoothly and quietly.
5. Check packing gland for excessive leakage.

If pump is not operating properly the fact should be noted on the inspection report and the equipment thoroughly examined and repaired at the earliest opportunity. A record of maintenance can thus be provided to determine the frequency of repairs and the need for replacements, thereby preventing emergencies.

Before disassembling the equipment or making any repairs, consult the manufacturer's drawings in the ''Operator's Data'' file in order to obtain a clear picture of the work involved.

Packing Gland

The packing gland of the pump is probably the most abused and troublesome part of the whole unit. If the stuffing box leaks excessively when the gland is pulled up with a *mild* pressure the packing should be removed and the shaft sleeve examined critically. If the shaft sleeve is grooved or scored, it should be replaced. You cannot hold packing in a stuffing box with a roughened shaft or shaft sleeve. When replacing the packing it should be replaced with cut rings, staggered and tamped in place before inserting the next. Never use a continuous helix or string of packing because it will either wrap around the shaft sleeve and score it, or it will be thrown out against the outer wall of the stuffing box, causing subsequent scoring of the shaft, by leakage of sewage through the packing.

The type of packing used is less important than the manner in which the packing is placed, but ordinarily most sewage plant operators like metallic packing. Some makers of metallic packing advise the use of alternate rings of hard and soft packing for best results. The operator should be sure the lantern ring is positioned properly.

If grease sealing is used, the lantern ring should be completely filled with grease before the remaining rings of packing are put in place.

The packing box is best protected with a clear water supply from an outside source with a pressure at entrance point not less than pump shut-off head. Occasionally observe the packing glands for leakage. A slight leakage of seal water, when pumps are running, must be permitted to keep packing cool and in good condition. The quantity is best determined by experience.

If excessive leakage is found, tighten the gland nuts evenly for a few turns. Do not draw glands too tight. After adjusting packing glands, be sure the shaft turns freely. If serious leakage will not stop, renew the packing and/or shaft or shaft sleeve.

When grease is used at the packing gland it is important that grease pressure be constantly maintained on the packing during operation. Spring loaded grease cups can be used and they must be kept loaded with special water pump grease. This is the same type of grease used in automobiles and is generally procurable at auto stores or service stations. The grease should be forced through the packing at a rate of about one ounce per day. This should be checked daily. Where temperatures are low and the grease is too heavy, thinning may be necessary.

Lubrication

The frequency of repairs may be directly proportional to the proper lubrication. Manufacturers make recommendations regarding lubricants to be used on their equipment. Oil companies will prepare recommendations after a review of your equipment.

In general, avoid building up high pressures inside of the grease chamber when lubricating equipment. This excessive pressure is apt to break down the grease seals which in turn cuts down the lubrication efficiency. It may also cause emulsification of the lubricant, breaking it down into components of oil, water and soap which rapidly corrode the bearings. Quite frequently, after a bearing has failed, it shows rust deterioration which is generally caused by high pressures as a result of over-greasing.

After pressure lubrication, remove the fitting and allow a few seconds for the excessive pressure to relieve itself before replacing the fitting. Many motor manufacturers, to avoid over-greasing, use a plug instead of a grease pressure fitting.

Bearings

If ball bearings are oil lubricated, keep the oil chamber clean and filled to the oil level gauge. A good grade of neutral, medium viscosity, mineral motor oil will usually be satisfactory.

Greasing schedules should be established according to actual experience based upon the number of hours each unit operates daily. The grease lubricant requires careful selection and, as pointed out above, should be recommended by the pump manufacturer or by an oil company. Only ball bearing lubricants should be used for grease lubricated ball bearings. Never use graphite.

Sleeve bearings should be checked daily and operation of oiling rings observed carefully. This type of bearing may be furnished with telltale oil cups which should be replenished with oil as required.

Ball bearings should be inspected daily. The bearing nearest the packing box may receive the most abuse and, therefore, give the most trouble. Sewage squirting out of the packing gland may find its way into the bearing housing and cause a bearing failure. This condition can be prevented by daily attention to the packing box. If a water slinger has not been provided between the packing box and nearest bearing, the manufacturer may be able to furnish one to prevent normal packing box leakage from traveling shaft-wise into the bearing housing.

When cleaning around a pump, the man applying the hose should be careful not to direct the jet of water directly against the ball bearing housing because such practice is most apt to result in water being forced into the bearings which may ultimately cause a bearing failure.

Misalignment

When the correct geometrical relation between the driving and driven elements of a pump or any other piece of equipment is not maintained, breaking or excessive wear must result in various parts of the equipment. Burned out bearings, sprung or broken shafts, excessively worn or ruined gears are a few of the damages resulting from misalignment. The damage can occur in either or both the driven machinery or the driver. Rather than wait until the damage is done, check the alignment of all equipment and thereby prevent many a headache and the expense of installing replacement parts.

The original installation of the equipment may not necessarily be the cause of the trouble. The settling of foundations, heavy floor loadings, warpage of bases, excessive bearing wear and many other factors cause misalignment.

Do not take for granted that a rigid base is security against misalignment. The base itself may have been mounted off level, which would lead to warpage.

Do not assume that a flexible coupling will permit misalignment. The coupling may be designed to stand misalignment, but the bearings of the pumps, motors and other machinery are *not* designed to carry misalignment. Generally speaking, large factors of safety are used in the selection of bearings, but not factors of safety which will protect the parts from the excessive loads caused by improperly aligned equipment. If you have to run equipment out of alignment, you *must* use flexible shafts with universal joints .

Flexible couplings permit easy assembly of equipment, but they have to be aligned just as truly as flanged couplings. Consequently, if maintenance and repair are to be minimized, alignment must be maintained.

Excessive bearing and motor temperatures caused by overload, noticeable vibration, or unusual noises may all be warnings of misalignment. If the installation is not too heavy, it may be possible to loosen the mounting bolts of the drive and by shifting it one way or the other the correct position may be obtained. Shimming of the drive or machinery will give vertical adjustment. Changes in degree of noise or vibration will guide your efforts.

Alignment of couplings can be made with a straight edge and thickness gauge and should be leveled up to within 0.005 inch to insure satisfactory operation. First, remove coupling pins. Then rigidly tighten the driven equipment and only slightly tighten the bolts holding the drive. By shifting or shimming the drive, the two halves of the coupling are brought into position so that no light can be seen under a straight edge laid across the coupling halves. The straight edge should be placed in four positions. Hold a light back of the straight edge to assist in determining this. This will correct horizontal and vertical misalignment. To check for angular misalignment use a thickness or feeler gauge at four places to make certain the space between the halves is equal.

Then tighten the foundation bolts completely and recheck the alignment. If proper alignment has been secured the coupling pins can be put in place easily using only finger pressure. Never hammer pins into place.

If equipment is still out of alignment repeat the procedure.

Vertical pumps are usually furnished with flexible shafting which will permit a slight degree of angular misalignment but when solid shafting is used alignment to the most exacting degree is absolutely necessary. If pumps with solid shafting are operated with any misalignment whatsoever they are almost bound to give trouble. If the beams carrying the intermediate bearings are not heavy enough or are subject to distortion because of contraction or expansion, this fault must be corrected and the greatest care exercised in re-aligning the intermediate bearing.

Chain or belt drivers must also be kept in alignment. Make certain that the driving sprockets, sheaves or pulleys are operating in the same plane as the driven units. This will eliminate excessive chain or belt wear.

Vibration

Vibration of pumps may be due to misalignment, but this is not the only cause. Even when alignment is perfect, vibration can be transmitted from the pump to the motor or from the motor to the pump.

Vibration can cause mounting bolts to work loose, excessive bearing wear, shake motor parts and electrical connections loose, crystallize metals to fatigue and numerous other damages. Because of this it is extremely important to eliminate vibration.

Generally, the source of vibration must be located by a process of elimination:

1. Tighten all foundation and mounting bolts.
2. Check pump, machinery and motor for loose parts.
3. Disengage drive and equipment. If the motor or drive operates more smoothly when disconnected, assuming proper alignment, then the machine should be examined for source of vibration.
4. Vibration may date back to repairs. In this case improper hydraulic balance of impeller or electrical balance of motor may be the cause. Generally, a plant is not equipped to handle these troubles and equipment must be sent out for check and repair. Consult your manufacturer.
5. Impeller may be out of balance hydraulically due to clogging, excessive suction lift or incorrect operating conditions. Throttling is one readily available method of checking the latter condition.

Loss of Capacity

When a pump has been found to fall off in capacity it should be inspected as a matter of routine before any extensive mechanical work is performed:

1. Be sure valves are open.
2. Clogging of the eye of the impeller, due to balling up of sewage strings or rags, will seriously reduce the capacity of the pump, or may stop it from pumping entirely. The inlet eye of the impeller is the most vulnerable point for centrifugal pump clogging and should always be checked first. If the pump is not provided with a convenient suction fitting with quick cleanout, a tee can be placed in the line adjacent to the pump suction so that routine inspection can be made from time to time.
3. The rotation of the pump should be checked since it is entirely possible that an electrician working in the plant might reverse the polarity, in which case the pump would run backwards.
4. An influx of sand into the pump suction will cause such rapid wear of the impeller that the pump is apt to fall off rapidly in capacity almost overnight. This condition requires replacement of impeller and adjacent parts also subject to wear.
5. Check the suction inlet for complete immersion. If inlet cannot be lowered, or if swirling eddies through which air is sucked persist when the inlet is lowered, chain a board to the suction pipe. It will be drawn into the eddies smothering the vortex.
6. Check packing box for intake of air at this point which would cause pump to lose capacity or even its prime.
7. Check the wearing rings on pumps so equipped. Where wearing rings are used they may be expected to wear out in relatively short periods and must be replaced, depending on liquid pumped.

Never, under any circumstances, attempt to metalize and turn wearing rings. They should be replaced with new ones, supplied by the orginal manufacturer.

8. Be sure discharge head is not too high. Check the discharge pipe line friction losses.
9. Be sure suction lift is not too great. Check for suction pipe line friction loss and be sure static lift is not too great. This may be measured with a gauge or mercury column while the pump operates. If you believe static lift is too great, proper steps must be taken to correct this condition. In such cases your engineers should be consulted.

   Check suction pipe line for air leaks and for high points which may allow air to accumulate, causing pump to lose prime.

   Be sure that taper eccentric fittings are used in pump suction line where pipe sizes change, to avoid air pockets. Be sure they are properly installed with the straight edge on top.

Supports

The suction and discharge pipe must not be supported by the pump under any circumstances. The piping should be shored up by concrete pedestals or hung from pipe hangers. If the pump carries the weight of the pipe it will throw the pump out of alignment, cause ultimate failure of some parts and may even snap off castings. This is one of the most common installation faults and cannot be stressed too much. Alignment of pump and prime mover must be perfect both before and after pipe lines have been connected.

Repairs

Impellers on centrifugal pumps are generally fastened to the shaft by a key and nut arrangement. If the impeller has been removed several times, sufficient looseness may develop to allow the impeller to wobble on the shaft. If the impeller has any wobbling tendency whatsoever, it should be eliminated by replacing both impeller and shaft. The close running clearance between the impeller hub and the suction inlet of the pump should be maintained or else the pump will lose greatly in efficiency and loss of power will result. If a close running clearance between the impeller and suction cover has been lost due to wear, it would be advisable to replace the suction cover or the impeller or to bush the suction cover with a ring to restore the original clearance. Some pumps are provided with a jacking arrangement on a retractile shaft so that this clearance can be maintained by a simple nut adjusting mechanism.

Bronze impellers generally wear the faster but even cast iron impellers and housings wear quite rapidly when any amount of grit is pumped. The pump impeller and housing should be inspected frequently for wear. If wear is noticeable, the parts should be replaced with new ones supplied by the manufacturer. Local repair of these parts may result in an unbalanced condition which can cause the pump to fail mechanically. Such local repair may also result in extremely bad hydraulic efficiency, increasing power cost many times more than the replacement price of the part. If the impeller is worn so that the diameter is materially decreased, the unit will fall off in both head and capacity as well as in efficiency.

Spare Parts

A reasonable number of spare parts should be kept on hand for each pump. The following materials are suggested:

1. A ball bearing of each size.
2. A supply of packing, for not less than three months.
3. Gaskets.
4. Grease and oil.

These suggestions are necessarily broad. For example, a pump operating 24 hours daily justifies a larger stock of parts than units used for intermittent or standby service only. Therefore, it would be best to check with the manufacturer for minimum spare parts stock recommendations.

Summary

Paint around a sewage treatment plant is attacked more rapidly than at other locations because of the presence of hydrogen sulfide gases and moisture. This necessitates periodic painting of all equipment.

By keeping the equipment properly painted, the appearance of your plant is greatly improved. Painted surfaces are easily cleaned and as a result aid considerably in the maintenance of the equipment. Furthermore, visitors are impressed and thus the plant becomes a credit to the community it serves. We should take great pride in our plants and do the best we can to maintain the best possible appearance, even though the personnel situation is extremely critical.

The life and the efficiency of the equipment are dependent upon proper maintenance given by the plant operator. The responsibility invested in him by the public must be felt and be met by his willingness to do everything possible to keep the equipment in good working condition and appearance. In this way the equipment will be always ready for economical and efficient service.

THE GADGET DEPARTMENT

A Visible Condensate Trap for Gas Meters

By H. A. Riedesel and John Wilgiert

District Engineer and Plant Mechanic, Respectively, Rockford Sanitary District

The condensate trap illustrated in Fig. 1 has been developed at the Rockford (Illinois) Sanitary District to afford convenient inspection

Fig. 1.—Visible condensate trap at sewage gas meter. Rockford (Illinois) Sanitary District.

and removal of moisture accumulations at the gas meter. Construction details of the device are shown in Fig. 2.

The sight glass which makes it possible to ascertain at a glance whether attention is required has been found distinctly advantageous.

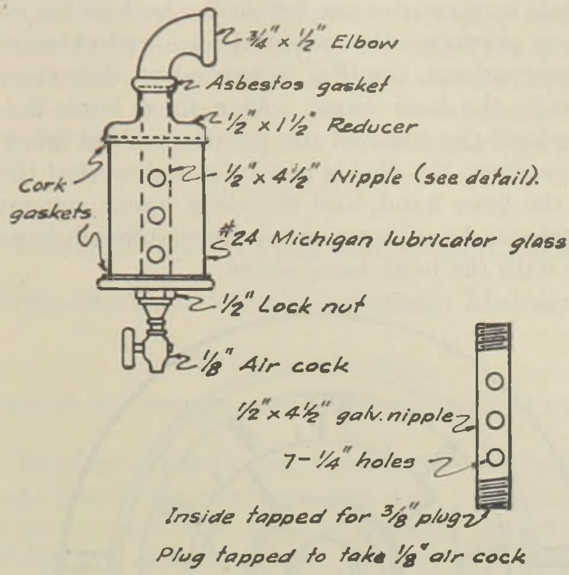


FIG. 2.—Construction details of gas meter condensate trap. Rockford (Illinois) Sanitary District.

Direct Reading Flow Dial on Electric Clock

BY A. A. HIRSCH

State Department of Education, Baton Rouge, La.

In many sewage plants unequipped with an orthodox type flow measuring device, it is nevertheless possible to determine the daily flow by means of a self-starting electric clock connected through a transformer across two phases on the cold side of the float-controlled switch to the motor driving the raw sewage pump. Usually the time in hours and minutes is noted during which the clock actually runs, and the flow is calculated by multiplying this figure by the pump capacity. These details are considerably simplified by mounting a specially ruled pumpage dial directly on the clock and arranging a zero point that can be conveniently reset each day.

On the clock illustrated in Fig. 3, a paper band (A), marked off in thousand gallon units, is glued to the glass dial cover—inside or outside will do. The glass must be free to turn in its groove. An annular paper band is selected so that the minute hand protrudes beyond the outer circumference, in this manner avoiding confusion with the hour hand. Another scheme for masking the minute hand consists of painting it out with a light color. A common rubber suction cup (C), such as furnished with many stick-on accessories for automobiles, provides a handle for rotating the dial. This method of resetting is easier than turning the hands by means of the key in the back of the clock, especially when the clock is permanently mounted on a switchboard.

To start observations, the dial is turned so that the arrow marked "SET" is opposite the hour hand. At a fixed hour the next day the pumpage is read off the scale at the position of the hour hand. After recording this reading, the dial is again turned so that the "SET" arrow coincides with the hour hand, and the clock again accumulates a registration. The minute hand is not used since sufficiently close interpolation is possible with the hour hand alone.

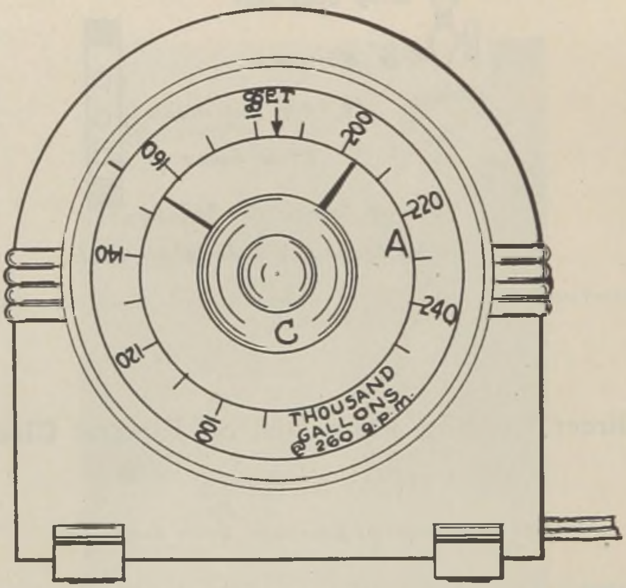


FIG. 3.—Electric clock with rotatable dial attached for totalizing sewage pumpage. Springhill, La.

Before preparing the dial illustrated, the regular duty pump was first checked by determining the rate of drop in the wet well within the usual limits of float elevation; this test showed a delivery rate of 260 g.p.m. The pumpage over 12 hours, a complete cycle on the dial, is then: $12 \times 60 \times 260 = 187{,}000$ gallons. That means the zero mark and the dial "SET" arrow coincide at 187,000 gallons. As this pump operates more than 12 hours per day, it is obviously unnecessary to provide rulings for very low pumpages; this segment of the dial is more effectively devoted to flows exceeding the 12 hour cycle of the hour hand. As divided in the sketch, the clock shows directly the pumpages ranging from 6 to 17 hours of net operation. A one hour or so gap is allowed for printing pertinent information.

When more than one size pump operates on wet well duty, separate clocks should be provided for each size pump and all their possible combinations. The daily flow then is the sum of their registrations. In many plants the float switch for the wet well may be so adjusted that a single properly selected pump will perform under ordinary circumstances. For this case, a single clock will measure pumpage except when rainstorms and seepage cause a high level and call upon the reserve pumps. A clock as described above is satisfactorily measuring influent flows at the Springhill, La., activated sludge plant.

SEWAGE PLANT MAINTENANCE ROUND-TABLE *

Electrical and Mechanical Equipment Maintenance

L. S. Kraus, *Leader*

Chemist, Greater Peoria Sanitary and Sewage Disposal District

Mr. Kraus: You have heard from the experts on this matter of pump and electrical equipment maintenance and now I would like to tell you a few of the experiences we have had at Peoria. Since little has been said about switchboard maintenance, I shall discuss this in particular. We make it a practice to test all relays at least every five years to determine whether these protective devices are affording the proper protection to the equipment. When you have protective equipment on motors, be sure the heater relays are the correct size. If a motor is burned out check immediately to see if the relays are of correct capacity. We inspect these devices to observe whether they are visibly in good shape and we do this frequently. Mr. Sperry asked about hydrogen sulfide in the corrosion of shunts; we use tin plates for shunts and inspect them frequently. The contacts on the magneto contactors are also of considerable importance and Dr. Hatfield at Decatur states that he coats these with some rust-inhibiting grease. We examine our contactor points daily and clean up any welded spots.

As to records, we keep good records of our electrical maintenance and we refer to them frequently. In addition to the records we have a good file of all of the information regarding every piece of equipment in the plant. We keep all dimensions—it is often difficult to get such information from the manufacturers. It is important now to have dimensions on whatever piece of equipment you have so that you can restore the equipment by welding, if possible.

As to pumps, we find our pumps to decrease in capacity as they become worn. There will also be a gradual drop in pumping efficiency which is quite important if you are buying power. We do not make a practice of buying new equipment when a pump becomes badly worn but, instead, rebuild the old equipment. We even consider it something of a waste of material to carry a lot of spare parts on hand. It also seems quite wasteful to place a bronze impeller on the scrap heap when it is relatively easy to build up the worn places with some bronze materials and have it turned or ground down to the original measure-

* Open discussion at Illinois Sewage Works Operators Conference, Springfield, Illinois, November 17–18, 1943.

ments. Here, of course, is where it is essential to have the detailed drawings and dimensions, since the machine shop must have this information if a rebuilding job is undertaken.

Perhaps the equipment manufacturers would not approve of our practice of rebuilding pumps but we feel it has saved us material, time and money. It has also given us a chance to experiment with different materials, for instance, we have found that chromium plated or stainless steel shaft sleeves give superior service. Of course, we supervise this work closely and, if we want to rehabilitate a highly specialized part, we do it in our own shop instead of trusting the job to the local machine shop.

We have a great deal of pump trouble and I dare say that at least one of our 25 or 30 units is always undergoing maintenance or repair. We find that pumps handling digested sludge are particularly subject to wear and require rebuilding every 6 to 8 months.

W. A. Sperry (*Aurora*): Do you find as a rule that you get better work at less cost when you have such work done at a local machine shop?

Mr. Kraus: Right now, at least, many of the factories are not greatly interested in the maintenance business at the present time but they are making an effort to take care of any work we ask for, as best they can.

In regard to packing of pumps, we follow a rather unorthodox practice which is not recommended by the pump or packing manufacturers, but gives us excellent results. We use a V-shape, already cut packing that has materially reduced the frequency of attention at the packing glands. We have also gone entirely to the use of water seals at the packing glands instead of relying on grease lubrication. If you are considering this, do not take water directly from the drinking water supply because that constitutes a cross connection. It is best to use a separate, auxiliary water supply for this purpose.

Painting Maintenance

W. D. Hatfield, *Leader*

Superintendent, Decatur Sanitary District

Dr. Hatfield: Painting maintenance is extremely important in any sewage treatment plant and you will undoubtedly have a good many questions. You may have two, three, four or as many as ten paint problems in a single plant. The paints must protect metals, concrete and wood, interior and exterior, exposed to the elements and to corrosive liquids and gases. Then we have complicated underwater corrosion problems as the two different situations encountered at primary and secondary tanks. There is still another problem at the outlet weirs of sedimentation tanks. There is no one paint that will be satisfactory under all these and the other difficult conditions we must contend with.

It is somewhat difficult at this time to discuss paints as they are all hard to obtain. In my opinion, tung oil is the basic ingredient of the best paints and it is on the most critical list of materials.

You should always buy the best quality paint available because most of the cost of a paint job is in the labor and there is no saving if the work must be done over after a short time.

For painting exterior metal, aluminum paint having a high grade varnish vehicle has been popular about sewage works. A sewage works operator can still purchase aluminum paint by making a special application but the varnish may not be up to prewar quality. After the war, we will all probably come back to aluminum and I recommend that you buy the best quality available from reputable concerns. Do not be guided by the cost alone, however, and be wary of the salesman who claims his paint is the best for every purpose.

Much emphasis should also be given the cleaning and preparation of the surface to be painted. The two most important elements of a good paint job are, first, proper preparation of the surface and, second, application of the best paint you can buy for the purpose.

C. D. Gross (Springfield): With regard to the preparation of surfaces which have corroded, have you had any experience with the rust removing material which is water soluble, eliminates sand blasting or other abrasion for rust removal, can be rinsed off with water and permits painting of the surface as soon as the water soluble application has dried? It can be painted within 5 or 10 minutes after drying.

Mr. Kraus: We used it a couple of years ago and found it particularly good for new painting because it forms a layer of iron phosphate on the metal which has certain rust-inhibiting qualities. You can use any good primer over it.

Dr. Hatfield: I have been using an iron rust remover with a good deal of satisfaction. It is made by the International Company of East St. Louis. The only difficulty is that it is supposed to stand on the rusty iron for 20 to 30 days before you brush it off and there is little equipment that can be left out of service for that length of time.

One of our worst problems is the protection of metal walkway gratings which rust badly. Our practice now is to spray them with oil every six months and this seems to stop the rusting. They are too hard to paint, anyway.

Mr. Kraus: We are encasing our gratings in concrete at the present time.

Mr. Pennington (Steger): Have you ever had experience with the product sold by the Texaco Company—a rust-proof paint called "No-Rust," I believe? It is something like a grease and must be cut with kerosene in cold weather.

Mr. Kraus: It is somewhat similar to "No-Oxide."

Mr. Sperry: After you use this product is it necessary to remove it and the rust?

Mr. Pennington: No, it is a protective coating in itself, just like a paint. It is supposed to be good for two or three years.

C. C. Larson (Springfield): We have had trouble with corrosion of our sedimentation tank chains and the last time we had them off we coated them with this Texaco product. That was about six months ago.

Mr. Sperry: Does it work equally well if the metal is submerged constantly or intermittently?

Mr. Pennington: It seems to make no difference. It remains sticky for some time and it is not necessary to wait until it dries before returning the equipment to service.

Mr. Sperry: Recently, in an industrial plant, I saw a substitute belt conveyor made of white pine which had been metalized with a zinc surface coating. It seems to me that this might be an excellent substitute for painting.

We have used on our clarifier mechanisms almost every paint that has been mentioned in these discussions and none of them have held up. The destructive action occurs when the tanks are taken out of service and left to stand idle. After the war we might find it practical to take the clarifiers apart and metalize the whole thing. My experience has been that painting may be forgotten for a long time on any metal covered with zinc.

Question: What do you suggest for painting the inside of the gas dome at a digestion tank? The Inertol people recommended a three-coat job.

Dr. Hatfield: I have mentioned tung oil paints for submerged work. There are also many bakelite paints advertised and Inertol has one at $4.50 or $5.00 per gallon which is satisfactory. We had fairly good results with a chlorinated rubber base paint several years ago on steel mechanisms.

Remember that the method of preparing the surface and applying the paint is just as important as the paint used.

Mr. Larson: As to the corrosion of metals, it was suggested to me recently that bacterial action is beginning to be suspected as responsible in some cases. I understand that chlorination is being used to control certain types of boiler corrosion. This is an interesting idea and suggests that paints which incorporate a disinfectant, such as those used on boats, may be the answer to some of our problems.

Dr. Hatfield: It has also been suggested to me that we try some of these marine paints. Many new coatings are being developed for that purpose at present.

Activated Sludge Plant Operation

C. C. Larson and Miles Lamb, *Leaders*

Chemist, Springfield Sanitary District and Superintendent, Belvidere Sewage Treatment Plant, Respectively

Mr. Larson: I should like to open the discussion by relating an experience we encountered in an aeration tank in which the air distribution became very uneven. Upon draining the unit, we found several plates, located at the end of the tank at the point where the flow crossed into the adjacent channel for the return pass, to have been worn through by abrasion. Several handfuls of rounded pebbles were found near these plates and it was evident that these had been trapped at the outer end of the first pass and could not move across into the return pass. As a result, they were carried around in the current of air and water and were brought constantly in contact with the diffuser plate surface, causing the plates to be damaged. This may have a lesson for designing engineers in connection with the discharge arrangement from one channel to the other.

Does anyone else have an interesting activated sludge plant experience to relate?

W. D. Hatfield (Decatur): In cleaning diffuser plates, we had always drained the tanks and washed them with acid which was quite a job. Just recently I tried adding chlorine to the air being applied through the plates because this is said to be an effective method of controlling clogging by organic growths, which is our trouble. I connected up a small cylinder of chlorine and fed about half of it into the applied air and when evening came I shut it off because it seemed to do no good. The next morning we found the air pressure had reduced a half pound. It seems that the action of the chlorine is delayed somewhat but the method is fairly successful. We like it because the tanks may be kept in operation while the plates are treated.

Mr. Larson: We had a little trouble with such growths on the plates. Many large plants have the same difficulty.

L. S. Kraus (Peoria): For the past year we have used a hot chromic acid solution for cleaning plates and have had striking results. We have found chromic acid to be worthless, however, on a wet plate. We dry the plates thoroughly before applying the acid, allowing the sun to shine on them if possible.

Mr. Brockway (Plainfield): We have mechanical aerators (American) and I have had little trouble except at the beginning when we had a loud rumble in one of the aerators. Investigation showed that it was out of adjustment and the noise stopped completely after we lowered the machine an inch and a half.

Mr. Larson: What about mixed liquor solids concentrations? Last October, I permitted the concentration to drop to about 700 p.p.m. for about six weeks, just to see the result. Mechanical aeration plants are commonly operated at about that level.

Mr. Miller (Great Lakes, N.T.S.): Our plant was originally mechanical aeration but has since been supplemented by diffused air because of our high B.O.D. We now operate with about 700 p.p.m. mixed liquor solids although we have had good operation at 1,300 p.p.m.

Miles Lamb (Belvidere): With Chicago aeration equipment, we carry 400 to 500 p.p.m. in summer and 700 to 800 p.p.m. in winter. This seems to keep the sludge from getting upset so easily.

Edward Watterson (*Salem*): I operate Simplex mechanical aeration equipment and find that 820 to 850 p.p.m. is satisfactory the year 'round.

Mr. Larson: Do you ever have bulking?

Mr. Watterson: Yes, the sludge does bulk at times. I control it by using copper sulfate. A nail keg with a perforated bottom is filled with crystals and a small stream of water is allowed to trickle down through the keg and out the holes into the return sludge channel. About one keg will stop the worst bulking we get.

Mr. Larson: I would like to know where you got the copper sulfate and the dosage rate at which you apply it.

Mr. Watterson: We had a barrel of it on hand before the war and are still using from it. The dosage rate must be learned by experience. My apparatus is rather crude and I over-dosed a number of times before I determined the right amount.

Mr. Miller: I have also used copper sulfate with good results, that is, for sphaerotilus bulking. I have also found that a good dose of supernatant to the aerators sometimes helps.

Mr. Kraus: We have had a lot of experience with sphaerotilus and have tried every method of control we have heard about but have not found any one remedy to work consistently. We have tried copper sulfate treatment of the sludge under careful control and sometimes it is beneficial, other times not. During a period of six months experimenting with copper sulfate we built up a surprisingly high concentration of copper in the sludge.

We rather prefer the sphaerotilus type of sludge, if it is not bulking too badly, because it gives better clarification and a clearer effluent.

Mr. Larson: My favorite remedy is to offer a fervent prayer for rain. I agree with Mr. Kraus' observation regarding improved clarification by a sludge having a slight tendency to bulk. Activated sludge that settles out of the liquor in big chunks does not give the clearest effluent.

Mr. Lamb: When do you consider bulking to be serious?

Mr. Larson: When the sludge index reaches about 300.

Mr. Lamb: At Belvidere (mechanical aeration) the index sometimes reaches 2,000!

Dr. Hatfield: We have always thought of bad digester supernatant as a common cause of bulking. I am surprised to hear it suggested as a remedy.

Mr. Lamb: When we were troubled with bulking we often discharged digested sludge to the aerators.

Dr. Hatfield: I could not get digested sludge into the aeration tanks without carrying it in a bucket so I probably will not try it.

Mr. Watterson: I never put supernatant into the aerators unless it is low in solids and high in ammonia, that is, it must be a good supernatant.

Mr. Kraus: This sphaerotilus is a facultative organism, that is, it will live in either the presence or absence of oxygen. It actually prefers an aerobic environment to an anaerobic one, so increasing the air may encourage its growth.

Mr. Larson: What about final settling tank sludge blankets? We consider it best to get the activated sludge back to the aeration tank as quickly as possible. If it were deemed desirable to create a slight demand for air it might be well to hold the sludge in a blanket for a time.

Mr. Watterson: If you carry a high blanket in the summer the sludge gets septic and will come to the surface.

Mr. Kraus: We have never been successful in holding any appreciable sludge blanket at Peoria for any length of time. We soon have the nitrites decomposing and rising sludge which passes over the weirs. This happens almost every week end when over-aeration occurs because the industrial load is suspended.

Another point about rising sludge. We have made some observations of the velocities at the bottom of the tank and have found them to approach one foot per second in some places just above the floor. It seems to me that this condition might be responsible for some of the rising sludge we experience.

Mr. D. E. Dreier (State Health Dept.): The rising sludge condition might be partially explained by the fact that unless the sludge is loaded sufficiently, or provided with food, it will tend to become buoyant and will not settle well. This would, of course, be an over-oxidized sludge, in which condition it will not settle and compact.

Mr. Larson: The answer might be to waste sludge.

Mr. Dreier: That might be the answer except that when the load falls off considerably for short times, it might be impractical to waste enough to eliminate the over-oxidized condition. Sufficient sludge must be retained to cope with the heavier loads anticipated to return.

Trickling Filter Operation

Floyd E. Johnson and W. H. Wisely, *Leaders*

Superintendent, Elgin Sanitary District and Executive Secretary, F. S. W. A., Respectively

Mr. Wisely: Let us open this discussion with the topic of settled sewage screens, often used to remove extraneous objects and material which clog nozzles and/or distributor orifices. As a starter, I will relate our experience at Urbana-Champaign where we formerly used ½-mesh wire basket screens at the spillway weirs into the twin dosing tanks. While these screens were in service, it was observed that the flow was divided into many fine streams, causing violent splashing as the sewage fell into the dosing tanks. This fine splashing caused considerable grease to agglomerate and float on the surface. When the tanks filled to the level of the starting well weirs, the grease would skim off into the starting wells which contain the control piping for the dosing tanks. We had a great deal of trouble with clogging of the air piping because of this grease until we placed shallow wood baffles at the starting well weirs to prevent the skimming action.

Eventually, we decided that the basket screens were not particularly effective in retaining nozzle-clogging material and removed them altogether. Possibly they would have been more useful if ¼-mesh screen had been used.

I cite this as an example of the settled sewage screen having more disadvantage than advantage.

Mr. Fuchs (Chanute Field): We have a single filter with a revolving distributor so we do not have the grease problem. We have a ⅜-mesh settled sewage screen which catches very little material. We rarely find it necessary to clean the distributor nozzles.

Dr. Hatfield (Decatur): We use ¼-mesh screens at the dosing tanks and they take out a lot of material, particularly in the fall when the leaves come down. We have not had the grease trouble although we have to take the tanks out of service occasionally to clean them up. We think the screens are very beneficial in preventing nozzle clogging.

Mr. Homer Fisher (Benton): Our filter is dosed with a revolving distributor and there is no dosing tank because we pump directly to the filter. We formerly had a lot of orifice clogging until I put a ¼-inch mesh screen at the primary tank effluent channel. This worked fine until this fall when a lot of leaves came down and clogged the screen overnight, almost causing a flood. I have not used the screen since because it is easier to clean the orifices than to handle the leaves.

Mr. Wisely: That brings up a good point. When such a screen is placed in any channel, we must not overlook the possibility that it may clog completely. There should always be overflow space left at the top so that the flow can spill over the screen if clogging occurs.

Mr. Miller (Great Lakes N.T.S.): We have made basket screens which are suspended in the opening where the settled sewage enters the effluent channel of the primary tanks. There is always some disturbance while the tanks are being skimmed and we drop these screens during the skimming operation and raise them afterward. Our main trouble is with orange peel.

Mr. Fisher: I thought of putting some screens in the primary tanks just in front of the weirs. We have a lot of trouble with hair and chewing gum at the distributor orifices.

Mr. Wisely: That is a good idea. I have seen slotted brass plates used in that way although I do not know where you could get the brass now.

Mr. Barger (Dixon State Hospital): My problem is with large rags and trash and I have been planning the installation of a bar screen having ½-inch openings behind the mechanically cleaned screen to catch whatever comes through the coarse screen. I would have to clean the second screen every morning, by hand.

Mr. Wisely: Yes, you do have serious screening problems in plants serving hospitals for the insane. I should think your two-stage screen idea might prove very helpful.

What about filter fly control? Several years ago, the State Department of Public Health sponsored a small research project on the effectiveness of the water springtail or *achorutes viaticus* for the control of *psychoda* flies. Mr. Corrington, what about your experience?

Mr. C. E. Corrington (Clinton): The springtails are still present in our filter from the original seeding about six years ago. They are most noticeable on the filter surface on cloudy days—I do not know why. We have practically no filter flies but we certainly had a lot of them before the filter was seeded.

During the past year we had a good deal of trouble with snails and fishworms in the filter and we chlorinated rather heavily to induce unloading. We were afraid this might kill off the springtails but it did not do so.

Mr. Wisely: Have you ever had any difficulty with pooling at the filter?

Mr. Corrington: We have not had any pooling since the filter was inoculated with springtails.

Mr. J. W. Debrun (Taylorville): We tried twice to seed our filters with springtails taken from the Clinton filter but they did not live.

Mr. F. E. Johnson (Elgin): At Elgin, we had a good growth of *achorutes* and when it became necessary to remove and rescreen the filter stone last year, we thought we would lose them. Both of our filters were out of service for four months but last spring the *achorutes* appeared again. All of the stone was thoroughly washed and, of course, the beds dried out. Nevertheless, the springtails survived.

Mr. Wisely: Does anyone have any experience to offer in regard to pooling control?

Mr. Johnson: Do you consider that a heavy algae growth at the stone surface might induce pooling? If so, would it be worthwhile to take the filters out of service for three or four days to dry out the growths?

Mr. Wisely: It is my opinion that a heavy surface growth could readily cause pooling. It is a little surprising that you would have such growths since your filters are so heavily infested with *achorutes.*

As to shutting down the filters to dry out the surface, I would rather recommend chlorination since you are equipped for it and disruption of filter operation would not be required. Application of 15 to 20 p.p.m. of chlorine to the night flow as applied to the filters should bring the condition under control in a few days.

At the Urbana-Champaign plant, I would much prefer to have the solids in the filter during the winter months than in the Imhoff tanks because of overloaded digestion and storage capacity. If the filter efficiency was satisfactory and if pooling had not yet set in, I would not be greatly concerned about the growths. No serious embarrassment should result if chlorination facilities are available since correction in a few days would be possible. I have never known chlorination to fail as a remedy or as a preventive of pooling if properly employed.

Mr. Fisher: At what time of year is pooling experienced at Elgin?

Mr. Johnson: Before the filters were rehabilitated, that is, when the surface stone was broken down to fine material, we had some pooling almost all the time. We have had no pooling since the filter media was worked over last year.

Mr. Fisher: We have pooling at the Benton filter every spring when a sort of rubber-like material collects on the surface. It is not deep and can be broken up with a rake.

Mr. Wisely: Mr. Fisher is referring to a substance which I heard best described by an operator as "hog hide." It is actually a heavy fungus growth which breaks loose from the sewers in wet weather during the spring and comes down to the plant in large clumps. It is brown when fresh but turns black upon decomposition and will often pass through the primary tanks to the filters.

One of the worst cases of pooling I have seen occurred at Polo, Illinois, due to the accumulation of this fungus on the filter surface. The only positive preventive that I can suggest is to retain and remove it before it gets to the filter. At Urbana, where screenings are ordinarily ground up and returned to the sewage, we always suspend grinding and proceed to bury the screenings at the times the fungus content is heavy. Temporary settled sewage screens are often advantageous when the fungus is being received, despite the difficulty in cleaning them.

Voice: We have had a lot of trouble with it. It comes down mostly after a heavy rain and we have tried to dip it out.

Mr. Fuchs: We have had difficulty at Chanute Field in winter with ice formation on the filter, causing interference with the rotary distributor. The ice built up around the perimeter of the filter and we solved the problem by replacing the conventional fittings at the ends of the distributor arms with wood blocks which directed a small stream of sewage straight down upon the stone. This eliminated the splashing against the filter wall. We went through the last winter without any ice trouble whereas we formerly had to get out there and remove the ice.

Mr. Wisely: That sounds like a very practical idea. The ice ring forms where there is a fine spray or splashing and your block would eliminate that condition. Ice rings will also form if the distributor orifices become partly or completely clogged, so it pays to keep them open at all times.

Mr. Fisher: We had a failure of the top bearing at our distributor last summer. I do not know why it failed; it had been operating for five years.

Mr. Wisely: After five years, a bearing at that place might be expected to fail. Faulty lubrication, improper alignment or use of the distributor as a merry-go-round by trespassing children are the most common causes of damage to that particular bearing.

Mr. Fisher: The entire case and ring was cracked. I have always used good, clean lubricant and the plant is fenced. We put the damaged bearing back while a new one is on order but the distributor stops every so often and it must be started manually. We have been waiting two months for the new bearing to be delivered.

Mr. Corrington: I have had to replace the same bearing twice in eight years, the last time since the war began, and had no trouble getting a replacement with our high preference rating. We change the oil at this bearing twice a year.

Mr. Clarence Matheis (Anna): Is there any danger of blowing out the mercury seal of the distributor if a water hose is used to flush out the arms? I just use a ⅝-inch garden hose.

Mr. Fisher: Open the ends of all the distributor arms and you will not break the seal—unless you used a fire hose under strong pressure.

Mr. Barger: How often should the mercury at the seal be removed and cleaned?

Mr. Fisher: I recommend that you leave it alone unless the seal is not holding. If the machine is in good working order and there is no surging at the inlet, you will not have much trouble. We operated four years without cleaning the mercury. The manufacturer of our distributor recommends that the mercury be left alone if it is causing no trouble.

Mr. Corrington: Have you any ideas on snails in trickling filters? We recently had to take 15 cubic yards of shells out of the Imhoff tanks, where they were carried with the secondary tank sludge.

Mr. Wisely: I, too, can testify that they are a nuisance when they get to sludge digestion units, but I think they are beneficial in the filters. We have a lot of them at Urbana but I believe the Decatur plant yields the largest snail crop in the state. I would like to call upon Dr. Hatfield but, unfortunately, we must defer the telling of any more tall stories about snails because our time is up.

FITTING A SEWAGE PLANT EFFLUENT TO THE RECEIVING STREAM

By E. J. M. Berg

Superintendent, Sewage Treatment Plant, San Antonio, Texas

There are two widely divergent views in regard to the use of rivers by man. One school of thought maintains that a river should be kept in all its original purity, or as Mr. Wolman put it in an address before the First Annual Convention of the Sewage Works Federation, "a water environment of the vintage of 1500 B.C., with an adjacent land environment of the chronology of 1940 A.D." The other school claims that the rivers are the natural drainage of the land, and hence should carry away whatever waste is produced.

Neither attitude is taken with full consideration of all the circumstances and of the rights of all that may have claim on the use of the river. I maintain that everybody living in the drainage basin of the river has a right to its use, and not only those whose property touches the river banks.

It is true that a river constitutes the natural drainage of the valley through which it flows but that does not mean that any group of inhabitants has the right to use it as a sewer, and thus destroy the potential uses that any other group of individuals might enjoy. It would be just as unreasonable to reserve a stream for a group of sportsmen to the exclusion of a thousand other men anxious to make a living in a paper mill. Some of you may remember that two years ago, in a talk made here, I stated that modern civilization has not yet learned to clean up behind it. Hence this disfigurement of our streams that we call pollution. Some day we will learn to clean up, but meanwhile we must find an "expediency index" as Professor Wolman stated in the paper referred to above, that is, a measure of maximum pollution so far as a polluting agency and its funds are concerned, but which can be removed by a river user below with a minimum outlay of his money. Such an "expediency index" might be called a standard of stream cleanliness; it will differ from the commonly accepted standard of cleanliness in that it is not rigid, but varies with the density of population, the industries in the river basin, and a hundred other factors. Each river, yes, each part of a river, is a problem in itself, and each sewage plant operator must study that part of the river that is influenced by his plant effluent, and solve the problem in such a way that his community gets its just use and enjoyment of the river without encroaching upon the rights of the communities downstream. He should give his plant effluent the lowest degree of purification that, considering the stream's ability of self-purification, will enable the future users of the stream to make use of it with the least possible outlay of money as is reasonable and comparable to the amount that his own community is spending for the purification of its sewage.

The stream's self-purification ability is of extreme importance. Of course, we know that a stream does not purify itself every 100 yards, or even every 10 miles. Unfortunately, there is no such convenient and tailor-made self-purification. The U.S.P.H.S. under the leadership of Streeter, Ruchoft, Kehr, and others has performed remarkable research work on self-purification of streams, developing mathematical formulas that enable us to see clearly what, so far as pollution is concerned, is actually happening in a stream as it flows along. Professor Fair of Harvard and his associates are working along similar lines, but with special attention to organic solids deposited in a river. SEWAGE WORKS JOURNAL, in various issues, presents the original papers of these researches, and "Modern Sewage Disposal" contains an excellent review of the papers written by Streeter. Let me present a typical problem and give an elementary solution.

It is quite definitely accepted that the dissolved oxygen in a stream should not drop below 4 p.p.m.; if it does drop below that figure, there is danger of objectionable conditions. Supposing a sewage plant effluent, having a B.O.D. of 15 p.p.m. and 2 p.p.m. dissolved oxygen, enters a stream flowing 10 m.g.d., having 8 p.p.m. of dissolved oxygen and a B.O.D. of 2 p.p.m. How many gallons a day can be permitted to enter the stream without danger of depleting the dissolved oxygen below 4 p.p.m.?

In solving the problem we must remember that the B.O.D. given is the 5-day B.O.D., which is approximately 70 per cent of the total, first-stage B.O.D. The total, first-stage B.O.D. in this case will be 21 p.p.m. for the effluent and 3 p.p.m. for the stream. If Q denotes the quantity of effluent in m.g.d., it must be such that the dissolved oxygen available in the river water and effluent will be sufficient to satisfy the combined oxygen demand of the river water and effluent and to leave a surplus of 4 p.p.m. of D.O. in the mixture.* The remainder of the solution of the problem is as follows:

Oxygen demand of river water $= 3 \times 8.3 \times 10 = 250$ lbs. per day
Oxygen demand of effluent $= 21 \times 8.3 \times Q = 175\ Q$ lbs. per day
D.O. available in river water $= 8 \times 8.3 \times 10 = 667$ lbs. per day
D.O. available in effluent $= 2 \times 8.3 \times Q = 16.7\ Q$ lbs. per day
D.O. desired in mixture $= 4 \times 8.3 \times (10 + Q) = 33.3\ (10 + Q)$ lbs. per day

These values make up the following equation:

$$(667 + 16.7\ Q) - (250 + 175\ Q) = 33.3\ (10 + Q)$$

Solving for Q, it is found that 0.44 m.g.d. of effluent can be discharged to the river to leave it in balance at a 4 p.p.m. dissolved oxygen content. If it is necessary to discharge more effluent to the river, the operator must either increase the dissolved oxygen content of the effluent or decrease the B.O.D., whichever is most feasible.

However, the problem does not work out quite so simply in fact. The stream studies by the U.S.P.H.S., referred to above, have brought out two important facts that I wish to mention here: first, as the stream flows on, it absorbs an amount of oxygen from the air that is not arbitrary, but is determined by the climatic conditions, the velocity of flow, and by the depth of the river; this oxygen will help to satisfy the oxygen demand of the effluent added. This is the so-called "reaeration capacity," and its magnitude can be calculated from the known conditions in the river and its observed characteristics (*This Journal*, March, 1935 and May, 1935). This reaeration enables the river to carry a load greater than was calculated above. Second, the self-purification capacity of the stream is measurably affected by the presence of sludge deposits. Where heavy sludge banks are present, the oxygen demand is frequently in excess of the reaeration capacity of the stream.

To fit the effluent to the stream which is to carry it, we must then do these things:

1. Reduce the suspended solids in the effluent at least to such an extent that, considering the velocity of the stream, no sludge banks will form. From 20 to 30 p.p.m. is probably safe.
2. Use any means within reason and possibility to increase the dissolved oxygen in the effluent; 2 p.p.m. should not be too hard to obtain.
3. The form of calculation given above will give a fairly safe amount of effluent for trial.

* This is a typical oxygen balance computation and gives a conservative result because it makes no allowance for oxygen taken up by the stream by reaeration or photosynthesis.

4. Take frequent samples along the river, not only within a mile below your outfall, but at stations several miles below the outfall, at least a few times a month, until you have become assured of the effect on the river.

We have had several experiences at San Antonio which will illustrate the application of a knowledge of the outlet stream. The effluent from our final clarifiers flows into a collecting channel, then it drops 18 feet through a 30-inch pipe down into the channel which carries it to the San Antonio River. This pipe opens about 2 feet above the water level in the channel, thus spraying the effluent through the air into the channel below. Dissolved oxygen tests in the collecting channel show an average content of between 1.5 and 2.0 p.p.m. Some 50 feet below the drop into the channel to the river, the dissolved oxygen is between 5.0 and 6.0 p.p.m., which appreciable gain is very much to the advantage of the plant and the river.

The effluent is chlorinated on its way to the river. Quite a number of special B.O.D. tests before and after chlorination were made. The average B.O.D. before chlorination is 30 p.p.m. and after chlorination it is 17 p.p.m., a reduction of 43 per cent and a very valuable additional treatment.

When we first began chlorination, we thought that a chlorine residual of 0.2 p.p.m. after 10 minutes contact was a safeguard to prevent pollution. We have had some experience that leads us to believe that there is very little or no relation between chlorine demand and B.O.D. of an oxidized sewage plant effluent. To get a 10-minute residual of 0.2 p.p.m. we must feed an average of 20 pounds of chlorine per million gallons. But we find time and time again that a highly treated effluent, one having as much as 6 p.p.m. nitrites and only 2 p.p.m. ammonia, may need some 35 pounds per million gallons, while a poor effluent, one having only 2 p.p.m. nitrites and 10 p.p.m. ammonia, may need only 18 pounds per million gallons to give the same chlorine residual. Our records show numerous examples, and we have become convinced that neither the chlorine demand nor the chlorine residual are true indices of effluent purification.

It is still true that the proof of the pudding is in the eating thereof and that is why the sewage plant operator must keep himself familiar with the condition of the river below his plant. He must not wait for sludge banks to appear (such deposits may completely overcome the self-purification ability of the stream); once they have appeared, their removal is not a small job. Watch for tell-tale bubbles in the quiet pools of the river. They might come from beginning sludge deposits, and a sample from the river bottom examined for volatile solids content might give interesting information. Watch for algae in these quiet pools. Green and blue-green algae are beneficial as they absorb carbon dioxide and set free oxygen in the water, and thus help toward purification of the river. However, a great increase of algae may be caused by overloading the river, and gray algae are a distress signal.

Frequent dissolved oxygen and B.O.D. tests of the river, with particular attention to their fluctuations, will tell the operator whether he is overloading the river or whether he is not taking full advantage of its power of self-purification. He should give serious study to an article by Schroepfer in *This Journal,* September, 1942. This is a very enlightening report on a long continued study of dissolved oxygen and B.O.D. tests on the Mississippi and Minnesota Rivers, from which I shall give just a few interesting details.

It was found that the dissolved oxygen content of a river varies not only with changing conditions, such as an increasing or decreasing pollutional load on the river, but it varies also with the depth at which the sample is taken; it is different at various hours of the day, depending upon the hours of sunshine; and it is different at varying distances from the bank. It follows then, that dissolved oxygen samples are not comparable unless the conditions under which they are taken are identical. A random grab sample is but an isolated test, and has really no meaning toward a study of river conditions. There is no such detailed information in regard to B.O.D. at different river levels or distances from the bank but there are considerable data regarding B.O.D. changes along the course of the stream, marking zones of pollution and zones of recovery.

The article is well worth serious study. Naturally, all the deductions from observations on a large and slow-moving river would not apply to a smaller and rapidly flowing stream but there is much information and guidance that will be of help to the man who wishes to use the river to best advantage.

To sum up, in order to fit an effluent to the river that is to receive it, the sewage plant operator must have a clear understanding of B.O.D. and dissolved oxygen; he must use chlorination wisely and not blindly; he must study the recovery power of the stream; and then use his knowledge thoughtfully and considerately.

TIPS AND QUIPS

Jargon from Jersey, when the New Jersey Sewage Works Association met at Trenton for its 29th Annual Meeting . . . a registration of 315, only 10 per cent below the all time high recorded for the Silver Anniversary meeting in 1940 . . . a postwar planning symposium featuring two municipal officials (Livermore and Paulus) who appreciate the value of sewage works . . . an enjoyable chore in presenting Federation awards to a pair of highly deserving workers; the Harrison Prescott Eddy Award to Harry W. Gehm and the Kenneth Allen Award to E. P. Molitor . . . an excellent exhibit arranged by Arthur T. Clark and the Water and Sewage Works Manufacturers Assn. . . . the annual dinner and entertainment, also arranged by the Manufacturers, at which the eight-piece orchestra comprised entirely of operation personnel of the Elizabeth Joint Meeting and directed by Acting

Chief Engineer Edward P. Decher "stole the show" . . . a symposium on sludge treatment and disposal that kept everyone in his chair until the last drying bed was cleaned . . . and a glowing tribute to the "World's Oldest Sewage Works Association" for the friendliness and hospitality shown its visitors!

In his 1942 Annual Report, Superintendent J. J. Wirts of Cleveland's Easterly sewage treatment plant refers to certain improvements to the four 54-inch comminutors which have resulted in a minimum of required maintenance at this equipment. The two most important changes were (1) replacement of the stellite cutters by others made of tungsten carbide which retain sharp edges much longer than stellite and (2) provision of a metal baffle at the base of the machines which reduces wear at the bottom of the comminutor drum and supplies a water seal to take the place of the standard neoprene seal.

Further improvement is expected to result when the supply of tungsten carbide is adequate to permit all shear bars and cutters to be made of this material.

Many thanks to those who answered our plea for sewage works pictures to decorate the walls of the Federation's new headquarters. It is much easier to get out the work now that a suitable atmosphere is provided.

We are still receptive to annual operation reports, however, and urge that we be placed on such mailing lists if we are not already included. Thanks again.

A bulletin covering experiences and recommendations in the elimination of gas hazards in sewage works, compiled in the Engineering Division of the Ohio Department of Health, will be found worthy of careful scrutiny by designers and operators.

The seriousness of gas hazards is given sharp emphasis by the reference to five serious accidents in Ohio which resulted in the loss of eight lives and in one near fatality. The report, prepared by A. Elliott Kimberly, Principal Assistant Engineer under the direction of Chief Engineer F. H. Waring, includes precautionary measures, lists of safety equipment and bibliographies.

If friends of Major Lloyd K. Clark are uncertain as to his present whereabouts, they may be interested to know that Secretary K. C. Lauster of the North Dakota Section of the Dakota Water and Sewage Works Conference has recently received an Australian pound note from Major Clark, in payment for his 1944 dues. Major Clark, now of the Sanitary Corps of the army, was formerly Chief of the Engineering Division of the North Dakota State Department of Health.

The General Electric Company has recently distributed two new bulletins which will be found extremely useful by sewage works operators. Bulletin GET–1195, entitled "How to Maintain Industrial Control," deals with the maintenance of electrical controls. Bulletin GET–1202 is entitled "How to Maintain Motors and Generators."

Both of these excellent handbooks may be obtained by addressing a request to the General Electric Co. at Schenectady, N. Y.

Advancing from Lansing, where the Michigan Sewage Works Association held its 20th Annual Conference on April 5–6 . . . a fitting and stirring opening ceremony in which an American flag was presented to the Association by N. G. Damoose of Battle Creek . . . a fine paper by Niles on the advantages of sludge as fertilizer followed by a rousing discussion . . . pleasure at seeing Secretary R. J. Smith doing so well in his long, hard fight to regain his health . . . a most effective get-acquainted stag featuring Col. Arthur Morrill's color pictures from India and Burma . . . the fifth hearing of "Blueprint Now" Filby's postwar planning oration, which we have now committed to memory . . . and why not? It's a splendid idea . . . the announcement that Tom Doyle of Pontiac is now eligible to join the ranks of the Quarter Century Operators Club . . . the conferring upon "Anse" Damoose of the "degree of B_1," after the famous Battle Creek Plant Food of the same designation . . . a thought-provoking dinner speaker who based his suggestions for a lasting peace in the belligerent Balkans on a first-hand knowledge of the people of that region . . . presentation of the Kenneth Allen Award to E. F. Eldridge in recognition of his long and faithful service to the M. S. W. A. . . . and congratulations to W. F. Shepard and his staff for an interesting, informative and well-managed Conference!

To eliminate excessive maintenance at a screw conveyor and bucket elevator used for handling grit, Superintendent George F. Wyllie at Lansing, Michigan, proposes to replace the equipment by using a removable dump truck bed as a receptacle for the grit as taken from the sewage and providing an electrical hoist mounted on an overhead trolley for moving the bed to and from the truck.

Appears to be a sound idea which should accomplish the desired results.

Another tip comes from Superintendent C. T. Mudgett of Muskegon, Michigan, where freezing of the material being carried up the grit washing and removal channel of a Dorr detritor had caused difficulty. Elimination of the trouble was readily effected by placing a winter cover over the unit and installing a burner using waste digester gas.

It now develops that the Battle Creek Plant Food (with vitamin B_1), which originates as digested sludge in liquid state at the city sewage treatment works, has properties not heretofore suspected. It seems that lawns which are soil-conditioned with this material are rid completely of moles, regardless of the severity of infestation before the treatment.

This unusual advantage of B. C. P. F. (with B_1) is reported by users of the material and it is not known whether other factors may have been responsible for the above phenomenon.

Can it be that a lone ray of sunshine is penetrating the bank of thunderheads which has beclouded civilian construction activity in recent months? An April news release from the Federal Works Agency lists 150 public works projects (all in the war-necessity category) which will total about $16,000,000 in cost.

Included in the list are 12 sewerage projects aggregating $1,862,000 in cost and four combined water and sewerage projects estimated at $1,104,000.

The following was related to us as a true story by the equipment manufacturer's representative who played the leading role. Name furnished on request.

Our friend had just checked in the hotel which was serving as headquarters for a sewage works operator's gathering, and being somewhat strange in this particular area (it being his home state), he approached a likely looking group in the lobby to introduce himself. After stating his name and shaking hands all around, he observed several puzzled looks and queried, "You men are here for the sewage works meeting, aren't you?"

"No," said one of the men, "we are onion growers."

Any embarrassment suffered by our well-meaning friend was quickly dissipated, however, when another in the group quipped, "That's all right, brother, you're in the right church but just got into the wrong pew!"

Editorials

COMMENTS ON SEWAGE SLUDGE AS FERTILIZER

The paper "Sewage Sludge as a Fertilizer" by A. H. Niles and contained in this issue of the *Journal,* provoked a most interesting discussion at the time of its presentation before the 20th Annual Conference of the Michigan Sewage Works Association last April. The paper was first discussed by a fertilizer chemist of the State Department of Agriculture, who typified the common conservatism of such workers toward the use of sewage sludge as a practical treatment for agricultural land. There followed a veritable deluge of indignant responses from the sewage works operators present in the session.

In a sincere attempt to view the sludge-fertilizer situation from an unbiased standpoint, we suggest that there are two distinctly separate parts to the question. First, there is the product of the large plant, usually heat dried, for which a market is sought either as a soil conditioner or as a base for fortified fertilizers. The second part, but by no means the least important, is the sludge produced at drying beds or vacuum filters in smaller plants, where the real problem is to get it off the plant property and revenue from its sale is secondary. The tendency has been to overlook the latter phase of the problem in the struggle to establish sewage sludge as a competitor to commercial fertilizers.

Because of the lower moisture content, heat dried sludge can be shipped at reasonable cost to users hundreds of miles from its source. Air dried sludge or vacuum filter cake, however, usually contains 30 to 50 per cent moisture and must find a use within fifteen or twenty miles of the treatment works. Having about 50 per cent volatile solids, 1.0 to 3.5 per cent nitrogen and a trace of phosphoric acid, the usual digested and air dried sludge is generally admitted to be as good a soil conditioner as well rotted manure. On this basis alone it should be possible to interest farmers located nearby to sewage treatment plants and even to justify a modest charge for the sludge. In some cases, local use of sludge may have gotten off to a bad start because it was originally "oversold" or distributed without instructions as to how it should be used to avoid odors and to derive best results. Preparation of the material by disintegrating at the plant may help move it where storage space is inadequate. Some practical "missionary" work among local farm advisers and farmers will generally suffice to keep the stock pile at reasonable size.

Much has been said recently about "plus values," or fertilizing properties in sludge which are not evaluated by analysis only of the nitrogen, phosphoric acid and potash contents. The writer confesses to a personal opinion that sewage sludge does produce better results than can be attributed only to the N–P–K ratio but must, at the same time, also confess that scientific studies do not as yet substantiate such an opinion. Perhaps we are encouraged by the enthusiastic reception of sludge by users in many parts of the country or by a natural desire to have the material accepted as a valuable by-product. It is hoped that sufficient interest can be created to encourage agronomists to extend their past investigations sufficiently to settle the "plus value" question in positive fashion.

Considerable research has already been conducted by state agricultural agencies and plot test results have not induced enthusiasm in these investigators. Some of this work is beclouded in the eyes of the sewage works operator because the agricultural researcher apparently did not understand that "sludge" is not a specific material but varies considerably according to the manner of its separation from the sewage and the biological and chemical conditioning it may have undergone. Other workers have studied it in comparison with the strictly chemical fertilizers which have little residual benefit after one growing season, instead of the organic fertilizers which are effective over several seasons. On the other hand, wishful thinking may be leading workers in the sewage works field into a feeling of impatience with agriculturalists, which feeling is not entirely fair or justified. The current impasse might be overcome if the U. S. Department of Agriculture undertook a study of several years' duration to investigate thoroughly, by approved methods, the efficacy of the various types of sludge (in the liquid and dry forms) in various types of soils in connection with the growth of major crops produced over the nation. Further investigation of the public health aspects could be included in this work.

For the present, the operator of the small and moderate size plant had probably best hold to a conservative policy in promoting agricultural use of digested, air dried sludge. It should be readily possible to establish an adequate local demand by convincing the farmers and county agents that sludge is at least equivalent to barnyard manure and by making the material available conveniently and in a reasonably dry and disintegrated condition. From the standpoint of the larger plants seeking revenue from the sale of sludge, it is not likely that the current demand and price levels will continue when chemical forms of fertilizers are released from wartime restrictions, unless the existence of unusual plant propogation qualities can be proven positively. A nation-wide approach to further research is certainly to be desired.

W. H. W.

THE PAPER SHORTAGE STRIKES

For the benefit of users of the *Journal* who may have noted that recent issues are not as bulky as corresponding ones of last year, we point out that the actual page content has not been reduced. Restrictions by W.P.B. have required us to use a 45-pound paper stock since the March issue instead of the excellent quality, 60-pound paper used previously.

While we may dislike the new paper because of its lower opacity, the change is only temporary and return to the heavier stock will take place as soon as the present emergency in the paper industry is past.

W. H. W.

Proceedings of Member Associations

MICHIGAN SEWAGE WORKS ASSOCIATION

Twentieth Annual Conference

East Lansing, Michigan, April 5–6, 1944

The Twentieth Annual Conference of the Michigan Sewage Works Association was held at Michigan State College, East Lansing, Michigan, April 5 and 6, 1944. As in the past, the Conference followed a Short Course School for sewage treatment plant operators under the direction of the members of the faculty of Michigan State College. Both elementary and advanced instruction was given. The school and conference are sponsored by the college, the association, and the Michigan Department of Health. Registration for the short course numbered thirty-five, and eighty-eight persons were registered at the Conference. The short course curriculum included:

Chemical laboratory analysis
Bacteriological laboratory analysis
Sampling and hydraulics
Chlorination
Sludge digestion

Papers presented at the Conference were as follows:

"Progress and Objectives of the Federation"—W. H. Wisely, Executive Secretary-Editor, Federation of Sewage Works Associations, Champaign, Illinois.

"The Practical Side of Safety"—W. D. Wilt, Safety Officer, Department of Water Supply, Detroit, Michigan.

"Sewage Sludge for Fertilizer"—A. H. Niles, Superintendent, Division of Sewage Disposal, D.P.S., Toledo, Ohio. Discussion by Percy O'Meara, Feed and Fertilizer Chemist, Michigan Department of Agriculture Laboratory, Lansing, Michigan.

"Maintenance Problems in Small Plants"—A round table discussion directed by C. P. Witcher, Superintendent, Sewage Treatment, Ann Arbor, Michigan.

"An Activated Sludge Plant on Chemical Process Wastes"—T. J. Powers, Waste Disposal Department, Dow Chemical Company, Midland, Michigan.

"Regulation of Sewer Use"—G. R. Sidwell, Staff Attorney, Michigan Municipal League, Ann Arbor, Michigan.

"The Why and How of Blueprint Now"—E. L. Filby, Field Director, Committee on Water and Sewage Works Development, New York, New York.

"Postwar Planning for Michigan"—Milton P. Adams, Executive Secretary, Michigan Stream Control Commission, Lansing, Michigan.

"Paying for Sewage Works"—N. G. Damoose, Director of Public Service, City of Battle Creek, Michigan.

Business Meeting

The Secretary-Treasurer's reports were read and accepted as read. New officers elected for 1944–45 were:

President	Paul Stegeman, Midland, Michigan
Vice-President	B. A. DeHooghe, Gladstone, Michigan
Secy.-Treas	R. J. Smith, East Lansing, Michigan
Director	C. T. Mudgett, Muskegon, Michigan

R. B. Jackson will continue as director and C. P. Witcher, Past President, becomes a director in accordance with the Michigan Sewage Works Association constitution.

Mr. W. F. Shephard, Michigan Department of Health, was designated to contact the Michigan State College Agricultural Experiment Station relative to undertaking an investigation of the value of sewage sludge as a fertilizer or soil conditioner.

Mr. E. F. Eldridge, Representative to the Federation Board of Control, has been assigned to duties with the 9th Service Command, and W. F. Shephard has been designated as his proxy for the duration of the military assignment.

Mr. W. H. Wisely, Executive Secretary of the Federation, made a formal presentation of the "Kenneth Allen Award" to Mr. E. F. Eldridge, Research Engineer, Engineering Experiment Station, Michigan State College, for outstanding service in the sewerage field.

A rising vote of thanks was extended to R. G. Foster, Assistant Engineer, Michigan Department of Health, in recognition of his service to the Association during the past year.

Smoker

A smoker and Dutch Lunch was held at the Forty and Eight Chateau, Lansing, Michigan. Program arrangements were under the direction of Messrs. Jackson, Stegeman, and Wyllie. Sound movies in technicolor were presented through the courtesy of the Michigan Department of Conservation.

Col. Arthur B. Morrill, United States Public Health Service, gave an interesting review of his experiences during a recent assignment to India and China. Col. Morrill's talk was accompanied by colored slides taken during his travels.

Annual Banquet

Ladies were invited to attend the Annual Banquet of the Association held at the Porter Hotel, Lansing, Michigan. A very interesting dinner address, ''National Problems in the Present Balkans,'' was presented by Dr. Paul Honigsheim, Ph.D., Associate Professor of Sociology, Michigan State College.

PACIFIC NORTHWEST SEWAGE WORKS ASSOCIATION

Eleventh Annual Meeting

Olympia, Washington, May 11, 1944

The Eleventh Annual Meeting of the Pacific Northwest Sewage Works Association was held in Olympia, Washington, at the Olympian Hotel on May 11, 1944.

Registration commenced at 12:00 noon with one hundred four members and guests attending. H. C. Clare, Chairman of the registration committee, was assisted by E. W. Gooch and Mart Early, in charge of registrations.

The meeting opened at 2:00 P.M. with Carl E. Green, Consulting Engineer, Cunningham & Associates, Portland, Oregon, presiding. Papers presented were as follows:

''Sewage Treatment Improvements at Walla Walla, Washington,'' by R. F. McLean, Water Superintendent, Walla Walla, Washington, and Emil C. Jensen, District Engineer, State Department of Health, Spokane, Washington.

''Sewage Effluent Chlorination,'' by Lieut. E. A. Bell, Sanitary Engineer, Office of Supervising Engineer, 13th Naval District, Seattle, Washington, and E. A. Heiss, Division Manager, Wallace & Tiernan, Terminal Sales Building, Seattle, Washington.

''Symposium on Postwar Sewage Works Developments,'' by E. L. Filby, Field Director, Committee on Water and Sewage Works Development, New York City, N. Y., C. M. Howard, Engineer, Concrete Pipe & Products Association, Seattle, Washington, Ben S. Morrow, City Engineer, Portland, Oregon, M. S. Campbell, Chief Engineer, Washington State Department of Health, Seattle, Washington, and H. C. Clare, Director, Division of Public Health Engineering, Boise, Idaho.

''Wartime Operating Problems,'' by William McNamara, Department of Streets and Sewers, Seattle, Washington, and James Morrison, Superintendent of Utilities, Renton, Washington.

The afternoon meeting adjourned at 5:30 P.M.

A banquet was held at 7:00 in the evening with M. S. Campbell, President, presiding.

The Kenneth Allen Award (the first one in this section to be presented) was awarded to Professor Fred Merryfield, Oregon State College, Corvallis, Oregon, "In recognition of the continuing years of tireless, unselfish and gratuitous service as Secretary of this Association; for his outstanding contributions to the progress and advancement in the science of sewage in the northwest, the Pacific Northwest Sewage Works Association grants the Kenneth Allen Award for 1943."

The award was presented by Wm. P. Hughes, Secretary-Treasurer of the Pacific Northwest Sewage Works Association, to the outstanding member of the section contributing to the advancement of the sewage-treatment field.

It was moved and seconded to instruct the Secretary to write Herbert Foote, Secretary of the Montana Section, and Joe Schmidtz, City Engineer, Lewistown, Montana, congratulating them on the formation of their sewage section and sending them copies of our new "Bylaws and Constitution."

Kenneth Spies presented the following resolution on the necessity of postwar sewage projects:

Resolution

Whereas, Many communities in the Pacific Northwest are now without adequate sewerage, sewage treatment and sewage disposal facilities, and

Whereas, The installation of new sewerage works and improvement of existing sewerage works is essential to the health and well-being of all peoples in the Pacific Northwest for recreational purposes, and

Whereas, The construction of new sewerage works and improvement of existing works will provide worthwhile and lasting benefits in the form of public works projects for immediate activation in the postwar period, and

Whereas, Municipalities which have at hand detailed plans and specifications covering postwar sewerage works construction will be in favorable position to take advantage of any postwar construction program,

Therefore, Be It Resolved, That the Pacific Northwest Sewage Works Association urge all municipalities to plan now for future construction and improvement of their sewage works to provide adequate sewerage systems and sewage treatment and disposal works, such planning to include the preparation of detailed plans, specifications and quantitative estimates covering the proposed projects, and

Be It Further Resolved, That the Secretary of the Pacific Northwest Sewage Works Association be instructed to prepare copies of this resolution and mail them to all incorporated communities in the states of Idaho, Oregon and Washington, comprising the Pacific Northwest Sewage Works Association.

It was moved by Milton McGuire, seconded by Ed. Heiss, and passed, that the Secretary be instructed to send the Resolution to all towns and cities in the section, also to Chester Biese, University of Washington, Association of Washington Cities, Seattle, Washington, and Herman Kehrli, Executive Secretary, League of Oregon Cities, Eugene, Oregon.

Mr. Ray Koon, Portland, Oregon, Chairman of Special Committee, discussed the revised "Bylaws and Constitution" and moved their adoption, which was carried unanimously. Mr. Koon also discussed the advisability of appointing a separate Secretary-Treasurer for the sewage section, due to increase in membership, which necessitates additional work, and due to increased importance in the postwar program. This was moved and carried unanimously.

The Nominating Committee, headed by Ray Koon, Chairman, recommended the following officers for the coming year:

M. S. Campbell........	*Director—Board of Control*
C. V. Signor..........	*President*
C. M. Howard..........	*First Vice-President*
H. C. Clare...........	*Second Vice-President*
Wm. P. Hughes.........	*Secretary-Treasurer*

The foregoing nominations were unanimously accepted.

Seven new members joined the Association at the Conference, bringing the total membership, as of this date, to 94, as compared with 85 last year.

WM. P. HUGHES, *Secretary-Treasurer*

MEMBER ASSOCIATION MEETINGS

Association	*Place*	*Date*
Dakota Water and Sewage Works Association (North Dakota Section)	Grand Pacific Hotel, Bismarck, North Dakota	Sept. 12–13
Rocky Mountain Sewage Works Association	Denver, Colorado	Sept.. 20
New England Sewage Works Association	Hotel Bancroft, Worcester, Mass.	September
FEDERATION OF SEWAGE WORKS ASSOCIATIONS	WM. PENN HOTEL, PITTSBURGH, PA.	Oct. 12–14
Pennsylvania Sewage Works Association	Wm. Penn Hotel, Pittsburgh, Pa.	Oct. 12–14
Canadian Institute on Sewage and Sanitation	Toronto, Ontario	Nov. 2–3

Reviews and Abstracts

H. Gladys Swope

California Sewage Works Journal, 15, No. 2 (1943)

Sedimentation. By Henry J. Miles, pp. 24–28.—All sewage treatment processes include sedimentation of solids. The fill-and-draw process would provide ideal settling conditions but is not practical because of the complicated operating procedure. Modern sewage treatment plants use the continuous flow type of tank. Most of these are equipped with mechanical means for removing sludge. Periods of 1½ to 3 hours are usually provided for in primary tanks, and periods of ½ to 1½ hours in final settling tanks.

Some of the common operating difficulties encountered are: excessive scum, high or low moisture content of sludge, and low efficiency of tanks. Excessive scum may be due to lack of proper grease traps on the sewerage system and septic sludge in tanks. If the former is the cause of the trouble a trap may be installed at the plant. Air may be used to aid in separating grease from the sewage. Septic sludge may be due to improper cleaning of the tanks or to septic sewage. Septic sewage conditions can be corrected to some extent by changing the pumping schedule. This condition can also be corrected by adding chlorine at intervals along the intercepting sewer.

One of the most common causes of low efficiency of removal is short-circuiting. This can be partially corrected in some cases by the use of baffles, finding the best location by trial. Other possible causes of low efficiency are excessive sludge depth, septic sludge in tank, and short detention periods.

Separate Sludge Digestion. By Harold L. May, pp. 29–35.—Separate sludge digestion is an important phase of some sewage treatment processes. Some of the reasons for the digestion of solids are: (1) the production of an inoffensive sludge through the breaking down of organic matter; (2) the reduction in bulk by liquefaction and gasification; (3) the increase in the readiness with which the sludge may be dewatered; (4) the production of a combustible gas which may be utilized; and (5) the production of a fertilizer.

There are three stages in the digestion process: (1) the period of intensive acid production, (2) the period of acid digestion, and (3) the period of digestion of more resistant materials. The three stages are in operation at the same time in a well controlled tank. The rate of digestion is influenced by seeding, reaction, and temperature. Proper seeding reduces the digestion period to about one fourth that required for unseeded material. As for reaction it is well agreed that a pH value of 7.0 is best. In a well operated tank seeding and reaction are both easily controlled. Industrial wastes may, however, upset conditions and give an unfavorable reaction. Temperature may be controlled by means of heating coils. The most favorable temperature appears to be between 82–98° F. for domestic sewage solids.

There are many designs for covered digestion tanks. In some the raw sludge is mixed with digested material before it is admitted into the tank. Others provide stirring devices to mix the raw and digested sludges, and another design provides recirculation of digested sludge through the raw sludge entry ports. In some cases two stages of digestion are provided.

Primary Treatment of Sewage with Combined Clarification and Digestion. By Gilbert C. Hanes and Roy E. Ramseier, pp. 35–40.—The septic tank is one of the earlier forms of primary sedimentation devices. They are commonly built with two compartments, with the first about twice the size of the final, and a baffle wall between them. Capacities are usually expressed in terms of hours of average sewage flow. A 24-hour capacity is common. In the operation of septic tanks it is very important that the sludge level be kept low enough so that the sludge will not pass into the final compartment. In the case of open tanks it is necessary frequently to break up the scum and thoroughly wet it by submergence.

The Doten tank is a modified septic tank and consists of three hopper bottom tanks in series. Sludge is transferred from the first and second hoppers, as they are filled, through sludge pipes to the final hopper. Removal from the final hopper is frequent and complete. As with open septic tanks, they require daily attention. Scum must be broken up and material that will not settle must be removed.

The development of the Imhoff tank afforded better control of the processes of sedimentation and digestion. In a tank of this type digestion is carried on in a separate compartment. Gas bubbles and gas-borne particles are kept from the settling compartment by baffles. However, solids passing through the slot to the sludge compartment are replaced by an equal volume of liquor that overlies the sludge. There is a further exchange between the compartments when the sewage entering the settling compartment is colder than the liquor in the tank.

Trickling Filters. By Frank S. Currie, pp. 41–45.—The trickling filter is the most reliable, yet the most abused method of secondary treatment. There have been many conflicting statements as to capacities, depth, size of filtering material, advantages of ventilation, and necessity of secondary sedimentation. There are many installations without adequate primary sedimentation and others without provision for final settling.

In the past few years many high-rate filters have been installed. These may be divided into two classes, those using high recirculation rates and those using low rates. The low recirculation rate filter is called the aero-filter. They have been designed for dosing rates from 18 to 36 m.g.a.d.

The high recirculation filters may be divided into two further classes, the first of which recirculates the filter effluent through the primary clarifier and is called the biofilter. Recirculation varies from 1 to 4½ for single stage filters and from ½ to 3 for each stage of the two stage filters.

The accelo-filter recirculates clarified filter effluent through the filter. Dosing rates of 10 to 12 m.g.a.d. with 100 per cent recirculation are recommended.

Chlorination. By Ruskin T. Gardner, pp. 45–49.—There are many uses for chlorine in the various stages of a modern sewerage and treatment system. Means for applying chlorine are particularly important during wartime when structures may be out of service due to bombing or sabotage.

The application of chlorine to the sewage stream should receive careful attention. The diffuser should not be placed near fittings or obstructions that cause noticeable turbulance. The depth of sewage over the diffuser should be at least two feet, preferably more. A mixing chamber may be found desirable in many cases. Such chambers should be designed for ample contact time with effective baffling.

Accurate figures for ranges of chlorine dosage cannot be given because of the many varying factors and the results to be accomplished. The following figures show the annual average use that might be expected if rates are adjusted to requirements.

1-Crude or settled sewage (fresh to stale)	5 to 12 p.p.m.
2-Crude or settled sewage (septic)	10 to 40 p.p.m.
3-Sprinkling filter effluent (normal)	2 to 5 p.p.m.
4-Activated sludge effluent (normal)	2 to 4 p.p.m.
5-Intermittent sand filter effluent (normal)	1 to 3 p.p.m.

Disposal of Sludge. By G. A. Parkes, pp. 49–55.—This paper will be published in SEWAGE WORKS JOURNAL (September, 1944).

Pumps. By A. B. Shearer, pp. 56–59.—This paper will be published in SEWAGE WORKS JOURNAL (September, 1944).

Maintenance of Motors and Electrical Equipment in Sewage Plants. By J. P. Price, pp. 59–64.—Proper care and maintenance of mechanical and electrical equipment is of particular importance in these times of critical materials and priorities. A maintenance program for electrical equipment should be planned before the equipment is installed in the plant.

Equipment, particularly motors, should be selected with due consideration to the conditions under which they must operate. All equipment should be readily accessible. Connections to motors and control should be oiled or soldered and then taped.

Motors subjected to moisture in transit or that have been idle for a long period should be dried out before being placed in service. This may be done by passing a current through the windings, using a low voltage. Heat can also be applied by use of an oven or by the use of a canvas covering and unit heaters. Whatever the method, the temperature should not exceed 90° C.

Motors should be cleaned periodically, the length of time between cleanings depending on the service. Dry dust is best removed by a suction cleaner with a long nozzle. A cleaning fluid can be used for removing grease, oil and sticky dirt. After cleaning fluid is used it is well to dry out thoroughly the windings and apply a high grade insulating varnish.

Proper lubrication of motors is very important, though bearings of modern motors require but infrequent attention. It should be remembered that over-oiling or greasing is as bad as insufficient lubrication. Too much grease may cause excessive bearing temperatures. It may also cause grease to be carried into the windings.

Sludge and Scum Removal Equipment. By Clyde C. Kennedy, pp. 64–67.—Failures of sludge removal equipment are relatively rare as such apparatus is of heavy construction, operates at slow speeds, and is protected by overload protective devices. This equipment should be inspected at regular intervals, properly lubricated, and kept painted.

Scum removal is more of a problem than sludge removal because of the wide range of materials and quantities. Mechanical devices for scum removal have been quite successful with light scum, but often fail under bad scum conditions. Scum troughs are difficult to adjust and either too little scum is removed or too much water is drawn with it. The vacuum flotation process may offer a possible solution to the scum problem.

Digester Heating and Mixing Equipment. By Vinton W. Bacon, pp. 66–72.—This paper was published in SEWAGE WORKS JOURNAL, 16, 534 (1944) (May, 1944).

Sewage Flow Meters and Registering Devices. By Ewald M. Lemcke, pp. 73–75.—The Orange County Outfall Sewer District is composed of some four cities and four sanitary districts. There are connections for other contributors who pay a rental for use of the sewer. The sewer is 26 miles long, with 14 flow registering stations and two booster pump stations. Weirs have been installed at many of the flow measurement stations, though pipe measurements of flow are made in some instances. The Palmer-Bowlus weir is favored. Circular conduit flow computations are based on the Manning formula. Flow through booster pump stations is determined from the time of operation of the pumps. Pump efficiencies are checked from time to time.

Paints and Painting. By H. W. Davey, pp. 76–80.—This paper is a summary of experience with paints at the Bakersfield sewage treatment plant. Keeping all surfaces adequately protected by paint is of great importance. Paints must be selected to protect against various conditions as encountered in different parts of the plant. Paints which are resistant to sunlight are found to be essential.

Man Power and Operation of Sewage Works. By B. D. Phelps, 80–81.—The San Diego plant was built by W.P.A. labor and was placed in operation June 15, 1943. When plans for operation of the plant were made Civil Service examinations were arranged but only six names were placed on the list. The program decided on was to use all men on the list who had previous experience and to augment their services with elderly men who were particularly fitted to operate the machinery.

Electric Maintenance and Repairs. By Alonzo Hatch, pp. 81–86.—Electrical equipment is efficient and dependable over a long period of time. Reliable and trouble-free operation will be realized if proper care and maintenance are given when the equipment operates under adverse conditions of heat, dampness, dust, and oil.

Electrical control and protective equipment must be kept in best operating conditions at all times. Any particular device should be used only for the function for which it was designed.

In cleaning motors dry dust can be removed by the use of air under low pressure. Care should be taken not to blow dust into the bearings. If air is not available a small vacuum cleaner and brush may be used. When oil and grease are present it is best to remove the rotor and carefully scrape off grease from the windings. Grease that remains can be removed by use of a solvent, after which drying methods should be used. After drying a good air drying insulating varnish should be applied.

Emergency Land Disposal of Sewage. By William J. O'Connell and Harold Farnsworth Gray, pp. 86–102 (with discussions).—This paper is published in SEWAGE WORKS JOURNAL, 16, 729 (July, 1944).

T. L. HERRICK

THE RETURN OF THE PULMOTORS AS A "RESUSCITATOR": A BACK-STEP TOWARD THE DEATH OF THOUSANDS

By YANDELL HENDERSON

Science, 98, No. 2556 (December, 1943)

The pulmotor, designed to remove poisonous gases from the lungs and blood and to induce a return of breathing in cases of partial drowning, electric shock and gas asphyxiation, although exposed and rejected thirty years ago is being reintroduced under another name as a "resuscitator." It is claimed that the lungs while being subjected to alternating positive and negative pressures are ventilated. In reality these pressures are useless unless they are so great as to induce mechanical injury. When the patient is unconscious the rhythm of such an apparatus is either discordant and out of step with the patient's breathing or the diaphragm resists the artificial respiration by contrary respiratory movements. Respiration is principally dependent not on the reciprocating reflexes of inspiration and expiration but on the chemical stimulation of the respiratory center in the brain by blood gases, particularly carbon dioxide, along with an adequate amount of oxygen. Carbon monoxide is not an irritant and even in amounts that are deadly it does not injure the lungs. Instead it combines with hemoglobin, the oxygen-carrying substance in the blood. Until the carbon monoxide is largely displaced from the blood the tissues of the body and particularly the brain continue in a state of oxygen starvation. Mere inhalation of oxygen to displace carbon monoxide from hemoglobin often failed to resuscitate. Pulmotors and "resuscitators" designed to furnish large amounts of oxygen to the lungs fail to accomplish this because natural respiration does not cooperate but rather opposes the action of the apparatus. Accordingly the mortality induced by carbon monoxide poisoning in New York and Chicago during the pulmotor's period, 1910–1922, was not appreciably decreased from the pre-pulmotor period. Autopsies have shown hemorrhage in the lungs which could only be caused by the mechanical damage done by the apparatus. Lung ventilation can be induced safely by natural ventilation when stimulated by inhalation of carbon dioxide. Administering 7–9 per cent carbon dioxide with pure oxygen while a large amount of breathing is induced eliminates rapidly the carbon monoxide and stops asphyxia. An inhalator based on this principle was devised by Henderson and Haggard but has not been patented.

The chief value of the manual method of artificial respiration is that it can be applied immediately. American Red Cross advocates (1) immediate manual prone-pressure artificial respiration and (2) simple inhalators as auxiliary aid; but it disapproves of the suck-and-blow mechanical devices. Between 1912 and the present time out of four reports of committees dealing with the problem of methods of resuscitation, three have condemned suck-and-blow apparatus. The committee of the National Research Council has also made an adverse report on suck-and-blow mechanical devices.

In the April 28, 1944, issue of *Science* appeared a reply by the Council of Physical Therapy of the American Medical Association in regard to the criticism of the mechanical resuscitators raised by Mr. Henderson. It is stated that modern devices are essentially different from the pulmotor which has not been in use for some time, insofar as they do not produce dangerous pressures. No evidence was found where the use of the accepted devices has led directly to loss of life.

H. HEUKELEKIAN

THE PROTOZOAN FAUNA OF SEWAGE DISPOSAL PLANTS

By A. Neville Barker

The Naturalist, July–September, 65–69 (1943)

The protozoan fauna of sedimentation tanks is restricted; ciliates being exceptionally rare. During aeration the fauna is characterized by a constant density of population and constant diversity of forms. The high bacterial content and the rich dissolved organic matter and salts in sewage along with the abundant supply of oxygen is responsible for the above phenomenon. The seasonal prevalence of certain types of protozoa commonly found in fresh waters does not occur frequently in sewage treatment plants because of the more uniform environmental conditions and the abundance and uniformity of food in sewage. There are, however, a few instances of seasonal behavior in the trickling filters. Naked rhizopods (*Amoeba actinophora*), small flagellates (*Oikomonas steinii*), and one or two ciliates (*Chilodon*) may be more prevalent in winter than in summer. Testate rhizopods, Euglenoida, and some ciliates show a preference for warm summer conditions. The putrefactive forms such as *Trepomonas agiles* and *Polytoma uvella* also increase in summer. Among the plants studied where the beds tend to become choked and foul, an increase in ciliates takes place following the spring slough. In another plant where the sewage is weak and the beds open, the protozoa are at a maximum just before slough. The paper contains a list of the various types of rhizopods, flagellates, and ciliates with their relative abundance in three trickling filter plants and an activated sludge plant in England.

H. Heukelekian

BASICITY FACTORS OF LIMESTONE AND LIME. EVALUATION AS NEUTRALIZING AGENTS

By Richard D. Hoak, C. J. Lewis and Willard W. Hodge

Industrial and Engineering Chemistry, 36, 274–78 (Mar., 1944)

A procedure for the determination of the basicity factors of limestone and lime was developed in the course of studies on the utilization of steel pickling liquor. The method provides a means of comparing the available alkalinity of these substances. Essentially the method consists in treating a measured amount of sample with an excess of acid and back titrating with 0.5 N acid. Preliminary treatment varies somewhat with each type of material tested.

The basicity factor of limestone, 200 mesh, was found to be 0.5231 by this method as compared with 0.5334 calculated from chemical analysis. The basicity factors determined on different mesh sizes of limestone indicated a much greater activity of the finer particle sizes (Table I).

Table I.—*Basicity Factor: Grams Equivalent CaO per Gram Sample*

Boiling Time Hours	Sample Ground to Pass Mesh No.				
	30	65	80	100	200
0.5	0.4443	0.4572	0.4798	0.4874	0.5231
1.0	0.4571	0.4879	0.5030	0.5153	—
1.5	0.4736	0.5088	0.5179	0.5244	—
2.0	0.4855	0.5211	0.5229	—	—
2.5	—	0.5249	—	—	—
3.0	0.4958	—	—	—	—

The basicity factors of lime determined by this method varied with the process of calcining and with the particle size. The samples examined showed a factor of 0.9340 for rotary-kiln lime screened through 80 mesh and 0.8880 for shaft-kiln lime screened through 30 mesh.

The determination can be accelerated by using HCl instead of H_2SO_4 (Table II).

TABLE II

	Acid	Time	Basicity
Limestone (as $CaCO_3$)	H_2SO_4	1 hour	0.5726
	HCl	1 hour	0.9185
Lime (as CaO)	H_2SO_4	5 minutes	0.6168
	HCl	5 minutes	0.8731

In studies on the disposal and uses of waste pickling liquor, the liquor was completely treated with lime. The advantage of a method for the rapid determination of the neutralizing value of the liquor was manifest. For this purpose the "acid value" method was developed. This provided a rapid means of determining the sulfate content of the liquor and is based on the theory that in the neutralization of pickling liquor an equivalent of sulfate ion combines with an equivalent of calcium ion to form $CaSO_4$, for each equivalent of hydrogen ion uniting to form water. By treating a measured amount of liquor with an excess of 0.5 N NaOH, filtering the precipitate, washing thoroughly, titrating the residual NaOH to pH 7.0 and finally computing the net NaOH required to grams of sulfate ion per liter, the sulfate content of the liquor can be determined.

The authors have used the basicity factor-acid value relation to obtain complete neutralization of acid and complete precipitation of iron from spent pickling liquor. It is important that the lime be completely slaked and that the mixture be thoroughly agitated during the reaction period. It is pointed out that dolomitic limes have an advantage over high calcium limes as less sludge is formed in obtaining complete reaction. It is also shown that basic open-hearth slag has relatively little neutralizing value as compared with lime and limestone.

The objective in the treatment of spent pickling liquor is to obtain a compact sludge and a neutral effluent which can be discharged into a sewer or water course (without deleterious effect) at the lowest possible cost. Pulverized limestone is the least expensive of the neutralizing agents. It produces a rapidly settling sludge and presents no industrial hazard. However the iron cannot be completely precipitated even with a large excess of limestone and the effluent produced would not be satisfactory without a finishing treatment with lime to raise the pH to 8.2–8.5.

Quicklime provides the highest available basicity at the lowest price. However the sludge produced has a very slow settling rate. Quicklime also is difficult to store and is a skin irritant.

Based on cost per unit of basicity, hydrated lime is the most expensive of the three neutralizing agents. It has, however, definite advantages in that it reacts quickly, the sludge settles more rapidly than that produced by quicklime and it can be stored reasonably well. It too is a skin irritant but can be safely handled with proper precautions.

E. HURWITZ

EFFECT OF WASTE SULFITE LIQUOR ON AGGREGATION OF SOIL PARTICLES

BY R. B. ALDERFER, M. F. GRIBBENS AND D. E. HALEY

Industrial and Engineering Chemistry, 36, 272–74 (Mar., 1944)

Experiments on the use of waste sulfite liquors as a soil amendment have demonstrated the beneficial effect of this material on the aggregation of soil particles.

The sulfite liquor used for these tests had been modified by chemical treatment to eliminate the more deleterious components and concentrated to 50 per cent solids in multiple effect evaporators. The material as used contained 6 per cent ash, 4 per cent non-fermentable carbohydrate, 5 per cent fermentable carbohydrate and 35 per cent lignin. The waste also contained calcium, potassium, sulfur and other minerals essential to plant growth but cannot be considered a fertilizer. Its value lies in the possibility that its lignin and carbohydrate components can improve the structural properties of soil through the formation of bacterial protein-lignin complexes.

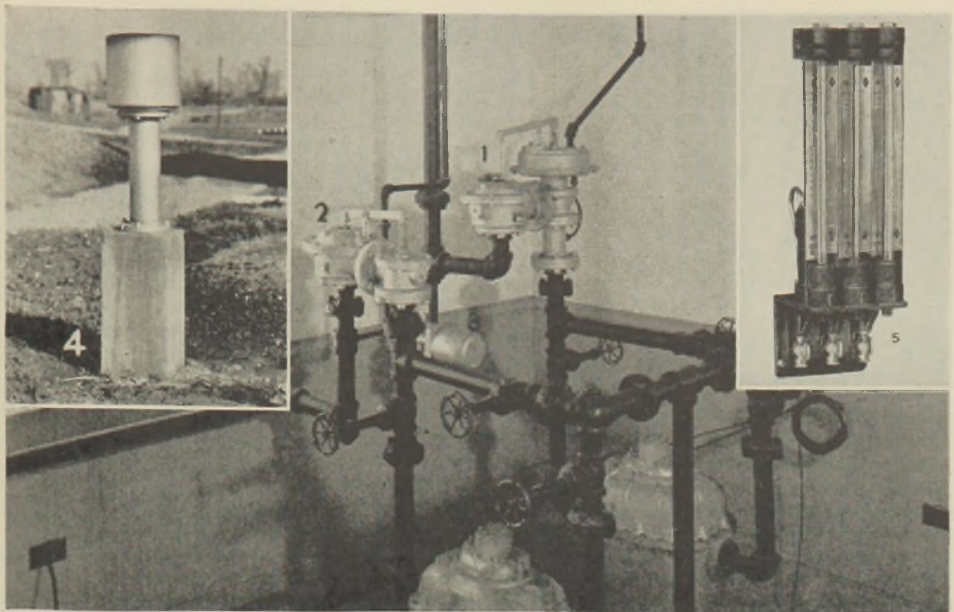
The degree to which particles of the original untreated field soil were aggregated into good tilth producing crumbs, following the addition of the sulfite waste liquor, was determined by structural stability and permeability measurements (*Soil Science,* 51, 201 (1941)).

The studies indicated that an excellent soil structure can be obtained through the judicious use of sulfite liquor. There was a considerable increase in the number of water soluble granules produced, as shown by aggregate analysis, which results in an increase in the probable permeability of the soil.

If used as a soil amendment, the quantity of sulfite liquor should not be so great as to cause a temporary cementing effect on the upper soil surface with consequent exclusion of air. Intimate mixture with the soil particles and a suitable interval (2 to 3 weeks) to affect the decay of the less resistant material should be provided. To insure more rapid and thorough decomposition, the addition of an ample quantity of a balanced fertilizer should precede the treatment. Such an application will prevent serious competition between soil organisms and crop plants for the mineral nutrients present.

The experiments indicated that optimum dosage was from 2.5 to 5.0 tons per acre, the larger dosage being applied after treatment with a balanced fertilizer.

E. Hurwitz



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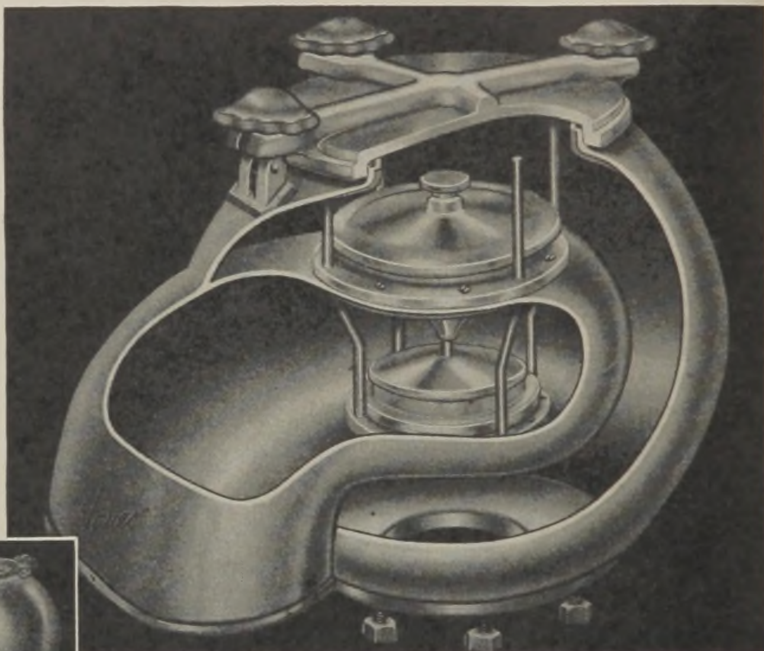

Cutaway Section of Figure No. 20.

"VAREC" *approved* Pressure Relief and Vacuum Breaker Valve.

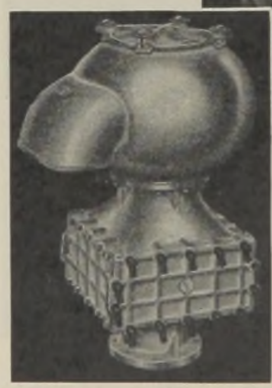

Figure No. 58.

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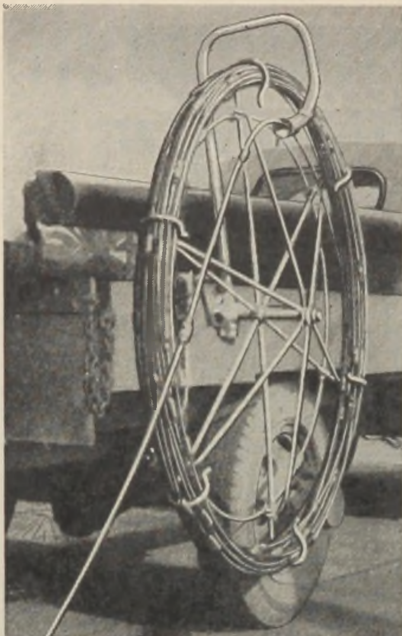

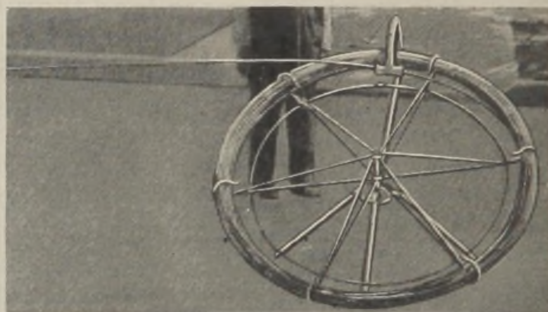

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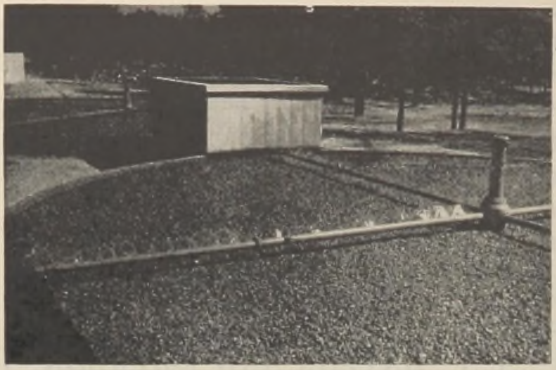

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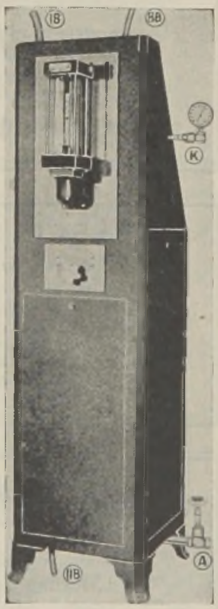

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