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Sewage Works

BRITISH DEVELOPMENTS IN SEWAGE PURIFICATION PRACTICE *

BY JOHN HURLEY

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On commencing this paper, my feelings are a fifty-fifty blend of gratification and regret. Gratification for the privilege of being permitted to submit a paper to your convention; regret that I cannot come with it.

It is obvious that, short of writing a book, I cannot deal fully with all that has happened in sewage disposal during the last ten years or so. I shall have to be content with noting some of the outstanding developments, and indicating some general trends in sewage works practice. It has been indicated to me that you would be particularly interested in developments in trickling filters; also in the question of industrial wastes, and how our 1937 Drainage of Trade Premises Act is being applied. I intend to be guided by this advice.

Present Conditions in Britain

I do not propose to say much on this subject, but it is worth a few words because existing conditions always have some influence on the direction and application of research.

You hardly need reminding of the difficulties under which sewage treatment plants have been operated in recent years—you have had some of it yourselves. Shortages of labor and materials, night-time operation under blackout conditions, shifts of industry and population, damage from bombs and other aerial ill-will tokens—these have all contributed towards making things difficult. But in spite of all this, sewage purification is much more effective in Britain than might have been expected. Of course, taking the country as a whole, constructional work in sewage works has been practically at a standstill since 1939. This, coupled with seven years of the make-do-and-mend type of maintenance, has inevitably had some effect. Taking things all round, however, the position as to sewage purification and rivers pollution is not as bad as might have been anticipated. Profiting from experiences of the 1914–18 war, after which many streams and sewage works were in a deplorable condition, most of us took care to start this war with the plant in good condition and some spares in stock. That was the one good point about the more recent war—you could see it coming, and take a few precautionary measures.

The effect of these arrears of repairs and new construction, and of restrictions on materials and labor, is obvious; many sewage works operators are most interested in developments which can be applied quickly for boosting the capacity of existing plants, rather than in those which mean tearing up the old plant by the roots and starting all over again.

* Presented at 19th Annual Meeting, Federation of Sewage Works Assns., Toronto, Can., October 7–9, 1946.

The Pioneer's Penalty

We in this country came into the sewage purification business early. We claim no particular credit for this; we were driven to it by circumstances. With high concentrations of population and industry on very small streams—as, for instance, in the Midlands—we just had to tackle the sewage disposal problem. My own town of Wolverhampton furnishes a good example. Of the three sewage plants which I control, two actually start the stream, while the effluent from the other plant discharges into a very small brook. Under such circumstances, there are only two options. Either you must get down seriously to sewage purification, or you kill everything in the stream for miles and miles and create all sorts of nuisances and dangers to health. Incidentally, in the latter case, gas masks would probably have to be made a standard item of apparel.

For this reason, most towns of any size have had sewage purification plants for many years. As a result, policy and development are bound to be influenced by the plant already installed. There is very real interest in all new developments both at home and abroad, and research and experimentation are active and thorough; also our plant manufacturers are always alert to evolve new ideas and to produce first-class equipment to meet the needs of new processes. Nevertheless, under the circumstances outlined, it is natural that those undertaking sewage works projects should be particularly interested in methods which can be applied to existing plants at small cost, and that their own research programs should be largely directed along these lines.

The existence of large and reasonably efficient plants at most towns means that most construction is in the form of alterations and extensions, rather than completely new installations. This cramps the style of the designer.

In consequence, the show plants of the past 15 years have been built at places which had previously done little in the way of sewage treatment, or in areas where the reorganization of sewage disposal on a regional basis has entailed the construction of a single large plant to take the place of a number of smaller ones. Instances of this are the several modern plants in Scotland, and the large Mogden works serving the West Middlesex area.

Now you see what is meant by "The Pioneer's Penalty." The town which approached the sewage problem promptly and courageously many years ago, now finds itself with a plant, which, although fairly efficient, is not as up-to-the-minute as some of those installed by the late starters. At the present time, few authorities can afford to discard an efficient but slightly out-of-date plant, and embark on a completely new scheme. I should add that finance is not the only factor involved. Arrears of housing, greatly accentuated by bomb damage, have made it necessary to give first priority to the provision of homes.

I next propose to consider sewage treatment stage by stage, giving a short account of trends and practice in each case.

Screening and Grit Removal

In older works, it was often the practice to provide fairly fine screening (say ¾ in. spaces between bars), and grit tanks of such design and size that in periods of low flow much organic matter was retained along with the grit. The separation and removal of the screenings and detritus was an obnoxious operation, and the ultimate dump was an unpleasant place to everything else except vermin. Current practice aims at reducing dumping to a minimum, and rendering the material inoffensive, while at the same time eliminating the heavy and dirty work formerly involved in these preliminary stages of sewage treatment.

Except in special cases, such as some seaside towns where screening is the only treatment provided, fine screening of sewage is practically obsolete. Some of the large works have discarded screening altogether, apart possibly from bars placed at 4-in. intervals or more, to keep back any very large masses which might occasionally come down the sewer. At smaller works, the nature of the screening depends on the type of plant, sizes of pumps and valves, etc., which are to be safeguarded from obstruction. At plants of medium size, bar spacings of the order of 1½ to 2 in. seem to be favored. In the new plants the screens are cleaned by float operated mechanisms, discharging the screenings on to a conveyor belt.

Disintegration of screenings, with return to the sewage, is used in some plants, and I have no doubt we shall see much more of this procedure in future works. The policy of screening the sludge, rather than the sewage, also has some support.

The separation of grit has attracted close investigation, with a view of designing channels with a constant velocity of about 1 ft. per sec. The chief methods for attaining this are channels of trapezoidal cross section, flow control by standing wave flume, and the provision of additional channels for use in periods of high flow. The grit is removed by scrapers, elevators or suction; at the small works hand cleaning of grit channels is still practised, but the plant is designed to make this relatively easy. In some works the separated grit is washed prior to ultimate disposal.

There is no general agreement as to which process should come first, screening or grit separation, but the tendency seems to be to make the screens (if any) the first stage of treatment.

Chemical Precipitation and Flocculation

Although the use of chemicals as an aid to sedimentation is not widely practised, quite a number of sewage plants use chemicals for certain specific purposes. Chemical precipitation is sometimes used as an auxiliary in overloaded plants, or to cope with abnormalities due to the presence of industrial wastes.

Some works in the wool districts of Yorkshire use sulfuric acid to "crack" the mixed sewage. The grease in the sludge is later recovered, either by hot pressing or by solvent extraction; it can then be refined by further acid treatment in lead-lined tanks, and sold. There is a regular and steady trade in the recovered grease.

The residual sludge remaining after the extraction of grease is dried and ground for sale as manure. Some of it goes direct on to the land; the remainder is sold to fertilizer manufacturers, who blend it with mineral fertilizers, or with such products as fish wastes, for marketing as a compound manure.

Another instance of the employment of chemicals in sewage works is the use of lime for neutralizing rushes of acid trade wastes, such as steel pickling wastes, plating liquors and galvanizing wastes. The manufacturers are generally supposed to discharge neutralized waste to the sewers, but it has been found good policy to have a liming plant at the sewage works, in case the manufacturer has an accident or his memory slips a cog. Such things do happen, and it is advisable to have a remedy handy. If your plant has been put out of gear by a rush of acid and soluble iron, there is small satisfaction in being able to say that it was the industry's fault.

Salts of aluminum and iron also find some use as aids to sedimentation, but their employment is not widespread.

Mechanical flocculation has not yet been widely used in sewage treatment in Britain, although it is quite common in waterworks practice in combination with chemical treatment. The results obtained on sewage, both on the large scale and in experimental work, have been fairly satisfactory but by no means sensational. The mechanical flocculation process, however, is not expensive, and I consider it is worth closer investigation, both alone and in conjunction with small doses of chemicals. I have a full scale experiment on this system in progress at one of our works, in parallel with tanks of similar size and design apart from the flocculating chamber, so I hope to find out something more in the near future. The results reported from this practice in America make impressive reading. I feel that variations in performance at different places are often due to apparently minor differences in technique, such as details of design, period of sedimentation and paddle speed. There is, of course, the usual difficulty that no two sewages are alike, and that the same sewage varies in properties from hour to hour—in fact from minute to minute. This does not make things easier in a process which probably depends on careful adjustment between a number of factors for full efficiency.

Primary Sedimentation

Perhaps the most striking characteristic of British sedimentation tank design as compared with practice in the United States is the large detention period provided. In the old days, when tanks were periodically desludged by manual labor, it was customary to design sedimentation tanks with a total capacity equivalent to 10 to 15 hours dry weather flow. Now that tanks of more advanced design are employed, with mechanical desludging gear, capacities equivalent to 6 to 8 hours dry weather flow are more usual.

Even these figures seem high compared with American practice, but when making comparisons there are a few factors which should not be forgotten. In the first place, British sewages are, on the average, much stronger than those met with on the American continent. Also, in times of storm, our plants are expected to provide full treatment for three times the normal rate of flow, plus partial treatment for everything above this rate. As we get our fair share of rainy days (a fact which those of you who have visited this country, will probably confirm with some emphasis) we must keep that triple load well in mind when designing sedimentation tanks.

It is also felt that liberal tank capacity has some value in ironing out sudden variations in the strength of the sewage, while in some works part of the settling capacity is used for balancing purposes to give a steady rate of feed to the biological section of the plant. This again is a valuable aid to operation, which cannot be effectively provided if the tank capacity is limited.

It is, of course, beyond dispute that granted something near ideal conditions, the solids removal per unit time decreases as the sedimentation period progresses. That is to say, a lot of solids are removed in the first hour, less in the second hour, and far less in the third, and so on. But ignoring the other considerations above mentioned, even a little extra efficiency in sedimentation may be worth quite a lot. For instance, in winter it may mean the difference between filters remaining open and efficient, instead of becoming clogged and ineffective. There is also the point that solids which are not removed in the primary tanks mostly crop up somewhere else —either in the final settling tanks or in the river. Knowing your high principles, I am sure you will not let them get to the river; so you get these extra solids as secondary sludge, which is difficult to dewater. There is, therefore, something to be said for removing them in the primary tanks.

I am not presuming to prescribe what is sound sedimentation practice under American conditions, but I feel that there is much to be said in favor of a 6- or 8-hour detention period under British conditions. In summer there is also something to be said against it—the danger of septicity.

On the actual design of sedimentation tanks, the trend is strongly for mechanically desludged types, either circular or rectangular. There is also keen interest in scrapers suitable for installation in existing rectangular tanks. Large tanks are not in universal favor. For example, in the case of circular tanks, some designers feel that units of up to about 60 ft. diameter, although more costly to construct on a volume basis than tanks of 100 ft. or more diameter, are more suitable for use in sewage works. The peripheral sludge is moved out of the tank more quickly and in a fresher condition; it has also been claimed that extra efficiency in the small tanks makes possible a decrease in total capacity.

The writer considers that, under most conditions, three tanks is the minimum for convenient year around operation. Even the best of tank mechanisms need some repair and maintenance. If there is only one tank, a breakdown is disastrous. If there are two, the tank remaining in commission must operate at 100 per cent overload. If there are three tanks, with one under repair, the remaining two are under 50 per cent overload. This is plenty, but in a well designed plant, on top of its job, it should suffice.

The Activated Sludge Process

Besides the diffused air system, several mechanical aeration systems have been in satisfactory service in this country for many years, and each system has its adherents.

Of the mechanical aeration processes, the commonest are:

1. The Simplex system, in which a "spinner" on the surface of the liquid effects aeration and mixing, and also induces a spiral circulation in the tank.
2. The Haworth (or Sheffield) system; in this process the functions of aeration and mixing are provided by large paddle wheels turning on a long horizontal shaft. The liquid proceeds through units divided into continuous channels about 6 ft. wide. In effect this is an artificial river, in which natural purification processes are greatly intensified, and recirculation (or dilution) is practiced.
3. The Hartley Spiro-Flow system, which in essentials is similar to the Haworth system, except that inclined paddles are used.
4. The Kessener brush aeration system, in which the aerating device is a revolving steel brush.

All these processes, like the diffused air system, can give good results at reasonable cost. Possibly most favored nowadays, at any rate for large plants, is the diffused air system, but the other processes have claims for consideration. One advantage of the diffused air system is its compactness, and the fact that within limits, aeration can be adjusted to suit requirements.

Plants of the Haworth type, for instance, need more space, as the working depth in the channels is only about 4 ft. 6 in. On the other hand, this type of plant has the advantage of positive dilution, as the liquid usually goes round the course about four times. This is a valuable feature in counteracting such things as rushes of strong trade waste. In this way the Haworth design does much to contradict the old statement that "activated sludge processes are easily upset by industrial wastes." From my own experience, I would say that this type of plant is quite good at absorbing a sudden heavy load, but it is not so happy when called upon to take a less striking overload over a long period.

A report has recently been given of a Kessener plant installed, slowly and painfully, at Rochdale during the war. The results are encouraging; the sludge elevating wheel used for lifting the activated sludge came in for a special word of praise. It has been found to be an automatic and very economical method for low lifts.

Trickling Filters

In recent years there have been so many reports on various modifications of trickling filter technique that it is impossible to do more than give a general review. Anyone needing more detail will have to consult the technical publications, particularly the *Journal* and *Proceedings* of the Institute of Sewage Purification.

Recent developments in trickling filters have been mainly concerned with the following aspects:—

Double Filtration

Double filtration is not new, but in late years the matter has been investigated from new angles. Much very thorough and important work has been carried out by the Water Pollution Research Board. This body is a branch of a government department, and its main activities are investigation and research on matters pertaining to rivers pollution and to the purification of sewage and trade wastes. Most of their work on double filtration has been carried out at the main plant of the Birmingham and Tame District Drainage Board, who handed over four ordinary circular filters, each 115 ft. in diameter, for experimental purposes.

The particular type of double filtration investigated by the Water Pollution Research Board is that known as alternating double filtration. In this process, the order of the filters is periodically interchanged. That is to say, the primary filter is transferred to the secondary stage, while the one time secondary filter is put to primary duty. When the process was first introduced for sewage treatment (it had previously given good results with milk wastes) many experts regarded it as illogical, on the grounds that the activities in a filter are more or less stratified. For this reason, changing the nature of a filter's feed and duties was felt to be unsound procedure. Indeed, although the process has given good results, criticism on these lines has not been completely stifled.

The experiments at Birmingham have been in progress for several years, using two filters for alternating double filtration, while operating another filter of the battery on conventional lines to act as a control. The dosage on the alternating filters has been gradually stepped up, and latest reports show the plant to be treating about four times the sewage per cubic yard of filter material, as compared with the ordinary filter. In most respects, the quality of the effluents from the two plants is very similar, the main difference being that the conventional filter gives a much higher degree of nitrification.

It is possible that the alternating filter plant has been pushed a little beyond the safety line, and that a dosage at three times the rate of an ordinary filter would better represent its capabilities. The increased efficiency of the alternating filters has been largely attributed to their ability to withstand clogging. The Birmingham sewage is prone to encourage a copious growth on the surface layers of filters, with a resultant loss of efficiency and capacity. This trouble is minimized by alternation, in two ways. First the growth which accumulates when the filter is on primary duty is weakened when the filter is on secondary duty. In addition, "film" is spread over much of the depth of the bed, whereas in a conventional filter it tends to form an impervious layer in the top few inches.

It is interesting to note that the bulk of the work performed by the alternating double filtration plant is done by whichever of the filters is on primary duty. The main function of the secondary stage appears to be recuperative. That is to say, when a filter has borne the brunt of primary duty, it uses the spell of secondary duty to get back into shape for the next primary round. It follows that for continuous efficiency the process depends on a good effluent from the primary filter. Otherwise, the required benefit would not accrue from the spell of secondary duty and the process would fall off.

During the earlier part of the experiments, the order of filtration was changed about once in three weeks, but a daily change-over is now preferred.

It has been said that the results obtained on the experimental plant should be used with some caution, because the plant does not operate under works conditions. In particular, attention has been drawn to the fact that the experimental plant is worked at a uniform dosage, hour by hour and day by day; a state of affairs far removed from the operation of an ordinary plant, which must take widely ranging flows as between day and night, and between wet weather and dry. These statements are true enough, and they have some force. But it must be remembered that the ordinary filter, used for comparison, also gets the benefit of a steady dosage in just the same way as the alternating filters.

The process has already had some practical application, and its employment at other places is contemplated. There have as yet been few details published as to the performance of these plants. From such data as have been made known up to now, it would appear that the alternating plants can carry a much heavier loading than ordinary filters, but the improvement is not so impressive as that achieved in the experimental plant. It may be that the Birmingham sewage, with its pronounced tendency to foster surface film, shows exceptionally high response to any process which prevents excessive surface growths. So few results have yet appeared on the performance of the process under normal works conditions, however, that it is too early to express an opinion on this point.

Besides the investigations on alternating double filtration, there has also been some experimentation on what might be termed straight double filtration, in which the filters are kept on the same job and in the same order all the time. Work at Huddersfield has sought to make use of the fact, demonstrated both in America and in this country, that quite a useful amount of purification can be effected by single filtration at very high rates. The method used in their experiments was primary high-rate filtration, followed by secondary treatment at a lower rate. So the process differs from most earlier double filtration schemes, in that the older plants generally worked both stages at the same dosage. Provided the small scale results were reproduced on the large scale, the newer type of straight double filtration would enable the unit dosage of the Huddersfield plant to be increased by about 60 per cent, as against an increase of only about 15 per cent obtainable by recirculation.

Recirculation

Recirculation, or the return of effluent for another pass through the filter, has been practised in this country for many years in the filtration of industrial wastes, particularly gas works liquor and chemical wastes. Thus, it is perhaps rather surprising that when American reports came through of the successful application of the process to sewage treatment about ten years ago, our technicians did not show much enthusiasm. In the last five or six years, however, there has been considerable interest in recirculation largely due to the possibility it offers of increasing the capacity of existing plants without spending much money or putting the works out of commission for a long period.

Perhaps the most interesting work on recirculation has been done by the staff of the Water Pollution Research Board. Like their experiments on alternating filtration, it has been carried out on a 115-ft. diameter filter at the Birmingham sewage works—the "spare" one in the battery of four taken over from the Drainage Board. The system of a uniform dosage was again followed, the recirculated liquor (settled filter effluent) being returned to the filter feed at a steady rate. The recirculation is on a fifty-fifty basis, one volume of returned effluent to one of settled sewage.

Two things are worth noting concerning the British approach to recirculation. In the first place, there is the low recirculation ratio as compared with American practice. This is not due to any distrust of your verdict that higher rates of recirculation give better results. The motive is economy, that is, to attempt to use recirculation in such a way as to economize on power and possibly use existing pumps; also to avoid extensions to the sedimentation stages and alterations to the feed lines.

The second point arises from the fact that most existing standard filter plants in Britain carry purification to a high stage of nitrification; figures of 40 or 50 p.p.m. of nitrogen in the form of nitrate are not uncommon, particularly in the summer months. This fact has much importance when considering the application of a limited degree of recirculation to increase the capacity of the plant. If high nitrification continues to prevail (and operators at many plants think this is desirable), the return of effluent to the primary tanks may be attended with some risk. It might lead to denitrification, with consequent "gas lifting" of the sludge by the gaseous nitrogen produced. Further investigation on this point is needed, but the results published up to now indicate that under British conditions, concentrations of nitric nitrogen in excess of 10 p.p.m. in the mixed liquors are liable to cause serious trouble in this direction. So, at the moment, direct recirculation of settled effluent to the filter feed seems to be the safer proposition under our conditions, and for our particular purpose.

Reports concerning the effectiveness of recirculation have varied widely, ranging from the previously mentioned small improvement at Huddersfield to the very striking performances of the experimental plant at Birmingham. The latter filter has taken dosages up to four times that of the conventional filter, with the production of an effluent of comparable quality in most respects.

Enclosed Aerated Filters

In this type of plant, the filter is completely covered, and positive ventilation is obtained by driving a gentle current of air downward through the filter. The process, which originated in Germany, has been the subject of searching investigation in Britain and South Africa. The British work, carried out by public bodies and industrial concerns, commenced about ten years ago.

Some of the experiments were halted or curtailed by the war, while industrial concerns are naturally shy of passing on information to competitors. In spite of this, considerable data have been published, and it is now possible to give a fair evaluation of the capabilities of the process.

Experiments carried out at Wolverhampton over a period of four and a half years showed the process to be capable of treating tank effluent at three times the rate of ordinary open filters, with the production of an effluent of similar quality. The experimental filter was 20 ft. in diameter with 13 ft. 6 in. depth of media, and great care was taken to insure that the filter had to take all the shocks normally experienced in works practice. It had just the same maintenance, by the regular plant personnel, and the dosage of the experimental filter was varied in the same ratio as the dosage to the main filter installation. This was not difficult, as the experimental plant was constructed alongside the flow recorder of the main installation.

All we had to do therefore, was to supply the attendants with a sheet having two parallel columns; in the right-hand column were the appropriate dosages of the experimental plant, corresponding to the main flow recorder readings shown in the left-hand column. By observing the two flow recorders, the attendant could tell whether the flow control valve on the experimental plant needed any adjustment. In the same way, by inspecting the flow charts each day, the management could tell whether the attendant had done his job properly.

Experiments at Halifax, mainly concerned with the purification of liquor from sludge treatment, confirmed the conclusions reached at Wolverhampton. But a works scale filter at Glasgow did not put up quite such a good performance, the enclosed filter taking about 2¼ times the dosage of the works open filters. This may be explained by the great depth of the Glasgow filter. This was constructed with a media depth of 18 ft., possibly with the idea of keeping down costs by making one floor and one roof enclose as much media as possible. However, some results obtained at Wolverhampton made it appear doubtful whether any depth greater than 12 ft. achieved much work; in fact, most of the work appeared to be performed in the top 9 ft. If this is so, it would explain the lower performance of the Glasgow filter as calculated on a cubic yard basis, for the bottom third of the bed may not have been earning its keep.

High-rate single filtration on an enclosed filter of 6 ft. depth and 20 ft. diameter was also tried at Wolverhampton, with very encouraging results. Operating on a strong tank effluent at a dosage of 1,000 gal. per cu. yd. per day, it achieved 70 per cent purification calculated on B.O.D.—a very useful performance for a high-rate partial treatment plant.

Now the war is over, we intend to alter the plant to work the two enclosed filters in series. During the war it was impossible to tackle this logical development of the research, owing to shortage of staff.

Now for a word on maintenance. The enclosed filters at Wolverhampton needed very little attention, either mechanical or manual. At Glasgow, there was some trouble owing to the accumulation of surface growth; this may have been due to the high surface dosage (consequent on the great depth), or to failure of scavenging organisms to establish themselves sufficiently strongly.

The enclosed filter system needs little space, and it is also claimed to eliminate odor and flies. To get out, gases and flies must pass downward through the bed; during the passage, the gases are claimed to be oxidized and the flies drowned. Experience at Wolverhampton supported these claims. No odor or flies were found in the outlet chambers of the deep full-treatment filter. In the case of the shallower partial-treatment filter, a few flies were occasionally found in the outlet chambers but there was no odor. It should be added that reports from Johannesburg say that, under their conditions, fly control by enclosed aerated filters is not so positive.

Cyclo-Nitrifying Filters

This type of filter was evolved at Sheffield to improve the performance of the plant at one of the branch sewage works. An activated sludge plant using Haworth paddles was finding difficulty in coping with a very strong domestic sewage. The condition of the activated sludge was not good, and the effluent was not always of the desired standard.

After prolonged experiments, in which several possible remedies were tried without much success, high-rate filtration of the final effluent was investigated. This was found to produce a highly nitrified effluent, which when returned to the activated sludge plant, brought about a big improvement in the quality of the effluent and in the condition of the sludge. The nitrified effluent was also found to be very effective for opening clogged trickling filters.

Distribution was found to be a crucial factor in the success of this process. Special jets had to be fitted to the works plant in order to reproduce the results obtained in the experimental plant.

Comparison of Methods

An accurate assessment of the relative efficiencies of the various new types of filter technique is as yet impossible, but I feel that you would wish me to make at least a rough comparison. To the best of my judgment, based on the data so far available, I should say that the three main processes rank about level. Given reasonably favorable conditions, alternating double filtration, recirculation on a fifty-fifty basis, and enclosed aerated filtration all seem to be capable of purifying sewage at about three times the dosage of a conventional filter, with the production of effluents of comparable quality. In no case, of course, is the increased efficiency obtained without some sacrifice of simplicity in design and operation.

Possible Combinations

The new developments in sewage filtration make possible many improvements in sewage treatment; in particular, a plant can now be designed to suit practically every set of local conditions and any type of sewage. The number of possible combinations, both among the various filtration systems, and between them and the activated sludge processes, must provide the conscientious designer with a first-class headache.

In England, partial treatment by activated sludge, in preparation for final purification on filters, has often been used. This has been claimed to be the logical sequence, as the activated sludge process shows up best in the initial stages of purification. But for that matter, so does any other process, for the Law of Diminishing Returns works as well for sewage as for anything else. The first bit of purification comes easily and cheaply, but each successive unit of purification becomes more difficult and more expensive. This is the reason why the assessment of performance in "pounds of B.O.D. removed" can be so misleading. A pound of B.O.D. removal at the tail end of purification takes more getting than several pounds in the initial stages. So this method of assessment does not mean much unless the comparison is made between processes giving the same degree of purification.

To my mind, as a result of my own investigations and of the results published elsewhere, there are many cases in which the reverse order of operation is justified. That is, partial treatment by high-rate filtration followed by final treatment by activated sludge.

Apart from series treatment, there is much to be said for having activated sludge and trickling filters in the same plant. It often happens that the filters tend to give trouble in winter and the activated sludge plant in summer. The seasonal adjustment of the load between the two plants, quite apart from any question of stage treatment, can bring about a substantial increase in overall efficiency.

Final (or Secondary) Sedimentation

On this aspect of sewage treatment, I propose to say little, except that trends are following the same general lines as for primary sedimentation. That is the increased use of mechanisms and hydrostatic head, instead of the old mud-pushing technique. Many authorities are intending to apply modern methods to existing installations as well as to new plants.

In my opinion, final sedimentation, particularly as applied to filter effluents, is still far from perfect. Short period quiescent settlement in the laboratory is often much more effective than relatively long period continuous flow settlement in the plant. Efforts should be made to bridge this gap, for it is undoubtedly the cause of much expense and stream pollution.

Chlorination of Effluents

Here, I know I am treading on dangerous ground. The chlorination of effluents, both partially and more fully purified, seems to be fairly popular in America. In this country, such practice is often looked upon as camouflage, or passing the buck to downstream districts. My own view is that while chlorination of effluents is justified in some cases to prevent local nuisance, as a general practice it is unjustifiable. For one thing I have never felt that enough was known of the possible effects of the chloro-compounds, which chlorine might form with the constituents of sewage, especially those containing industrial wastes; we know some of the complications which can be caused by chlorine compounds of phenols, and there is no reason to suppose that they are the only possible trouble raisers. Moreover, I have no use for a sterile stream. We should aim higher—at a stream replete with animal and vegetable life.

I have information indicating that valuable experimental work will shortly be published, which will make the advocates of universal chlorination of effluents do a bit of second thinking.

Sludge Disposal

During the war, the agricultural use of sewage sludge has boomed, and the present policy is all toward application of sludge to the land, either alone or blended with other fertilizers. Individual policy is based on local conditions. If there is plenty of agricultural land within a few miles of the sewage plant, sludge (preferably digester) can be pumped out in the liquid state. Depending on the length of freightage, in other cases the sludge may be either dried on beds, or pressed, or heat dried to about 10 per cent moisture. Incineration is regarded as a waste of energy and good material. All the same, some large authorities near the coast still barge their sludge to sea—which is just as wasteful, but less troublesome.

The collection and utilization of digester gas for power generation and other purposes is growing. During the war quite a lot of compressed sludge gas was used as motor fuel for cars and publicly owned vehicles. Some of it was used for making a particularly devastating type of fire bomb. It has been said that this is probably the only recorded instance of sewage being used as a weapon of war.

Two-stage digestion is popular here, both stages being of about the same capacity; frequently the primary stage is heated, the secondary cold. Sludge thickening, before digestion, seems to be gaining favor.

General Trends in Sewage Disposal

From the foregoing, it will be seen that two of the main trends in British practice, in common with that in America, are intensification and mechanization. Intensification makes possible economies in construction and in site area, while mechanization cuts out a lot of unpleasant and uneconomical manual jobs. The latter is necessary for a number of reasons, one of which is that of obtaining workmen to do the jobs. The workman of the future will not tolerate heavy and obnoxious work, which his education shows him could be better done by machinery. The old type of long-suffering, patient muck-walloper is on his way out, so plants which needed this type of labor must go out with him.

Two other characteristics are worth noting. One is the growing realization that the engineer, the scientist and the operator must work in close collaboration right from the inception of a scheme, if the best results are to be obtained. It may happen that the designing engineer himself has the necessary intimate knowledge of treatment processes and works operation; if not, he should seek the collaboration of specialists in these lines. Sewage purification is now such a huge and involved subject that there is no disgrace in admitting that all the necessary knowledge is not to be found under one hat. This close collaboration is vitally necessary to insure efficiency, economy and convenient operation. A works which is difficult to service is liable to suffer neglect.

It is also increasingly—but still not sufficiently—recognized that a sewage plant must be designed as an entity, not just as a collection of individual bits and pieces. Blend, balance and mutual suitability of the different stages are important. Growing importance is also attached to designing each works individually, to suit local conditions and to make full use of local facilities, both in regard to the selection of purification process and of methods of sludge disposal. The habit of adapting an old plan to another scheme is no longer approved in high places. Some designers are still too prone to this procedure, but their days are numbered.

There is also a growing inclination to treat sewage disposal on a regional basis, and to encourage small authorities in the same drainage area to get together for sewage purification purposes. Wholesale centralization is not very popular, but the need for providing plants big enough to carry proper technical and maintenance staff is generally admitted. Alternatively, there is the policy of having a number of small works under a single Board for administration purposes. Some of these Joint Sewage Boards have been in successful operation for many years.

In consequence of the government's policy—a sound one—of taking piped water supplies into more rural communities, there are going to be sewage disposal problems of a special type in these areas. The accepted view is that wherever possible there should be amalgamation of a number of village sewer systems to a single treatment works, or to the sewage works of a neighbouring town.

Industrial Wastes

Those familiar with British technical literature will have read quite a lot about our Public Health (Drainage of Trade Premises) Act of 1937. To those of you, if any, who neglect this opportunity of broadening your views and irritating your tempers, I can offer only one or two notes on the main features of the Act.

The chief object of the Act was to give all manufacturers, subject to certain conditions and safeguards, the right to discharge industrial wastes to the public sewers. In turn, the public authorities were given certain rights, including those of making the manufacturer provide sufficient treatment at the factory, when necessary, to protect the sewers from damage and to give the sewage works a reasonable chance of doing their job. The right to make a fair charge for the treatment of industrial wastes was also conceded.

In practice, however, the main fault

of the Act has proved to be the preservation of what are known as "prescriptive rights of discharge." Under these clauses, a manufacturer who has previously been discharging industrial wastes to the sewers can continue to do so indefinitely under the old terms—if any. This protection holds so long as the discharge remains of the same "nature and composition" and does not exceed its 1936–37 maximum rate. This means that, as far as old customers are concerned, you are pegged back into antiquity, with little hope of release unless the manufacturer contravenes the terms of the Act. The Act has other blemishes, but all the others are minor compared with the prescriptive rights.

The usual practice at the moment is to use the Act, with some caution, for new connections to the sewers. The compilation of a register of discharges, with definition of each firm's prescriptive rights, has made little headway in most towns. Naturally enough, this sort of thing, which involves an enormous amount of unproductive work, had to wait during the war years, and we—the sewage works profession—are now working and praying for a repeal of the prescriptive right clauses.

My own views on the Act, and a possible method of improving it, were set out in a paper which I presented at a meeting of the Institute of Sewage Purification in November, 1945. Entitled "A National Policy for Trade Effluents," it aimed at evolving a system which would give all industrialists and all public authorities an even break on the industrial wastes question. Naturally, one of the prerequisites of the system was the abolition of prescriptive rights, as only this could make fair and uniform dealing possible. Surely, if any firm should pay for the treatment of its industrial wastes, it is the one which has been loading its treatment costs on to the rate-payers for the past 30 or 40 years.

For the aims and possibilities of this scheme, I refer to the original paper. The suggestions it contains have, in the main, had a favorable reception, although not all technicians like the national aspect of the scheme. Some of them were up in arms against the scheme at the beginning, but a more careful reading of the paper has altered their attitudes. The recommendations aim at local control and operation, with just sufficient national coordination to make consistency possible.

The chief object of my proposal is equal charges for equal services. That is, equal charges for the same type and strength of industrial waste wherever it is produced. The charges would go into a national fund, from which each sewage authority would get a rate of payment depending on the degree of purification provided at its sewage works. In other words, payment by results.

Lest it should be thought that the Drainage of Trade Premises Act is altogether bad, may I say that it is probably a good deal nearer perfection than anything in existence in most other countries. It tried to do a big job, but was unsound on one or two points. Experience has demonstrated its shortcomings, so we are seeking something better.

The technical problems connected with industrial waste treatment are under active and continuous examination. Much has been accomplished, but plenty remains to be done, particularly in view of the changes in industrial processes.

Conclusion

In limited space, I have tried to give you a general picture of what is happening in sewage treatment in Great Britain, and to convey an idea of the trends.

I should have liked to present the paper in person, so that we could have exchanged ideas. Also, I feel that I am depriving you of one of the privileges of a technical audience—that of taking issue with the author. I shall, however, be glad to answer any queries in writing.

There can be no doubt that the getting together of technical men of different nations is a good thing, whether it be in writing, or better still by personal contact. It makes for mutual improvement as technicians, and for mutual understanding as men. My own impression is that international understanding and tolerance is more easily obtainable by technical men than by politicians. Technicians can hold different opinions without losing tempers; this cannot always be said of politicians. Also, the technician values facts, and seeks the right way, even though in the past it may not have been his own way. Whereas the politician . . . but perhaps I had better leave it at that.

BRITISH DEVELOPMENTS IN SEWAGE PURIFICATION—A DISCUSSION

By F. W. Mohlman

Director of Laboratories, The Sanitary District of Chicago, Chicago, Ill.

Those of us who have read Mr. Hurley's many papers in *The Surveyor* and the *Proceedings* of the Institute of Sewage Purification feel that we know him by his works, both by the pen and the plant. His comments are pithy and to the point, and carry authority of his position as President of the Institute of Sewage Purification. Therefore, we in the U. S. and Canada feel honored that he has taken time to send us his viewpoint of British developments in sewage treatment practice, and it will be my function to comment briefly on only a few points of his excellent paper.

The longer detention period in settling tanks has been a superficially important difference between British and American practice, but actually not so great as appears at first consideration. In Britain 6- to 8-hour detention periods are now common, indicating some reduction from the former periods of 10 to 15 hours D.W.F. Mr. Hurley has mentioned the greater strength of British sewage, frequently averaging only 50 to 60 U. S. g.c.d. American sewages vary from two to five times this volume; therefore the actual *tank capacity per capita* in both countries is not greatly different, except in some American plants which provide only 30 to 60 min. detention period, such as those at Chicago, Buffalo, Detroit and Minneapolis. Also, the frequent necessity to handle three times D.W.F. at British plants reduces the settling period to around 2 to 3 hours, within the range of many American plants which provide only sedimentation.

It is evident, however, that the British detention period is somewhat longer under summer dry weather conditions, leading, as Mr. Hurley states, to some danger of septicity. This hazard is somewhat modified by the lower temperature of British sewage in midsummer, as compared with our high mid-west temperatures.

The trend toward shorter detention periods is, however, apparent in both countries. If sewage can be passed through the plant without odors, it seems preferable these days to shorten the detention period so that only the more easily settleable solids are removed and discharge of effluent may occur before septicity has developed. Likewise, mechanical removal of sludge is characteristic of American plants, also leading to minimization of odor.

A more conservative policy is also

Military Trickling Filter Plants
Summary of Operation

No. Plants	Group Designation	Range of B.O.D. Loading (lb. per acre-ft.)	B.O.D. Efficiency, Filter and Sec. Settling (%)	Overall B.O.D. Reduction (%)
4	Deep, No Recirc.	253– 429	86.9	92.7
4	Deep, Recirc.	245–1,170	85.7	90.8
8	Two-Stage	192– 930*	66.5*	90.2
4	Shallow, Recirc.	705–2,080	81.7	88.1
4	Deep, Recirc.	1,190–1,950	78.7	87.5
3	Deep, No Recirc.	720–2,130	75.7	82.8
3	Deep, Recirc.	2,520–5,750	70.3	78.3
4	Shallow, Recirc.	2,370–8,250	70.1	74.8

* Second stage.

common in England with reference to rates of trickling filter operation. The various modifications of filter operation described by Mr. Hurley—(1) alternate double filtration, (2) recirculation and (3) enclosed filters—are rated as three times the rate of single-stage filtration. But even so, these accelerated rates are far below rates of American high-rate filters. I had occasion to compute the relative rates last winter and found that the loading as expressed by pounds of B.O.D. applied per acre-foot varied from 200 for normal filters to 600 lb. per acre-foot for the three types of British filters.

American high-rate filters operate above these rates, but there is the question of relative effluents. British standards require completely treated effluents, with around 90 per cent reduction of B.O.D. and production of substantial amounts of nitrates. American high-rate filter effluents do not meet these specifications. There is, of course, the question of whether nitrates are necessary, and in many cases less than 90 per cent reduction of B.O.D is satisfactory for American conditions of disposal. For production of the same quality of effluent, American rates of filtration are not appreciably higher than British. High rates are obtained only by some sacrifice of quality of effluent.

In our study of trickling filters serving military camps, the various filters were classified in the following groups:

The first group, with loadings from 253 to 429 lb. B.O.D. per acre-foot, gave an overall reduction of 92.7 per cent. Then the next two groups, with loadings up to 1,170 lb. per acre-foot, gave 91 per cent reductions. The two-stage filter at Fort Frances E. Warren, with a loading of 678 lb. per acre-foot, gave 7.0 p.p.m. nitrite plus nitrate nitrogen in the effluent. This was about the highest loading at which nitrates were produced in substantial concentration.

When loadings reached 705 to 2,130 lb. per acre-foot the B.O.D. removals dropped to 85 per cent, with no nitrate. Higher loadings gave reductions of only 75 per cent.

These results with strong sewage are somewhat comparable with English results, and indicate that nitrate production, the time-honored function of a trickling filter, marks the difference between high- and low-rate operation. British filters of the various types studied and discussed by Mr. Hurley are still in the low-rate class as judged by American standards.

American practice with strong sewage shows a trend toward multi-stage filters, with roughing filters, first-stage and second stage if necessary, followed, as Mr. Hurley suggests, by activated sludge treatment (as at Sioux Falls). This requires ingenuity to prevent rising sludge in the final tanks, but rapid removal of sludge may prevent this phenomenon from becoming troublesome.

Cyclo-nitrifying filters proposed an interesting procedure for using nitrate, if such filters could be justified in connection with a non-nitrifying activated sludge plant, but the cost appeared excessive for consideration at Chicago.

Mr. Hurley does well to call attention to the fallacy of estimating the cost of removing so many pounds of B.O.D.—whether it is the head end or the tail end of the process.

His remarks on chlorination of effluents are intriguing, especially with reference to the research results that have not been published. These results will be studied with interest in America, where our sewage menu is so often ended with a chlorine demi-tasse.

Finally, Mr. Hurley has suggested a scheme for controlling industrial waste disposal that is worth consideration in Britain but is not practicable in the United States. It should be easier for Britain to abolish "prescriptive rights" than for the U. S. to get 48 states to agree on one national law to control all industrial wastes.

On behalf of the Sewage Works Federation, I wish to thank Mr. Hurley for sending this interesting and thought-provoking summary of the status of sewage purification practice in England.

IMPORTANT CONSIDERATIONS IN SLUDGE DIGESTION. PART I.—PRACTICAL ASPECTS *

By Harry E. Schlenz

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Considering the extensive literature on the subject of sludge digestion and the experience gained by the operation of installations representing over 80 million cu. ft. of digestion capacity in the United States since the first heated separate sludge digestion tanks went into successful operation 20 years ago, it would appear that very little might be added by further consideration of the subject. Reference might well be made to one discussion in particular, which was presented before this Conference in 1931 by R. A. Allton. The writer has made practical use of some of the advanced ideas presented in that discussion of 15 years ago, having expanded and confirmed by plant operating data the curves and theories suggested at that relatively early time. If time were available it would be interesting to review Allton's contribution in view of our present day knowledge.

Despite the fact that the digestion of sewage solids has developed into an important and economical part of any sewage treatment process, the design and operation of sludge digestion systems has not been given the consideration it deserves, and it is the writer's opinion that the digestion process has not yet reached the degree of perfection of other sewage treatment processes.

Digestion tanks have been considered mainly as holding basins of a capacity to provide a retention time on a displacement basis of 30 days or more, and have been operated as a "take up" in the sewage treatment process to accommodate the optimum schedules of other portions of the system, without regard to the maintenance of proper conditions for digestion. Where operating difficulties have been experienced, the trouble has been generally diagnosed as lack of capacity, with additional digesters being added or recommended, while proper digester control might have been the answer.

During the past few years we have been confronted with the problems of digester operation in concentrated form. Municipal installations have been called upon to handle greater digester loadings due to increased populations without being able to add to the digestion capacity. Digester systems at military and naval installations were called upon to take full design loadings and even loadings greater than anticipated, from the first day that sewage was turned into the plant, thereby lacking the benefit of additional capacity allowed in normal designs by a projection of the population into the future.

The experience gained in correcting conditions of design and operation found at such installations has indicated the importance of (1) the provision in the design of digestion systems of necessary connections, devices and procedures and (2) the knowledge of the operating personnel of the fundamentals of digestion. These fundamentals are necessary to allow the practical application of the utmost in digester control.

The digestion system, if properly designed and operated, can serve as the "take up" in the sewage treatment

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plant, receiving solids and scum from clarifiers on a schedule favoring the operation of such units, with solids withdrawn from the digester system in amounts and at intervals to suit best a drying bed or incinerator schedule, and still be effective in performing its major role of destroying the organic matter in the sludge, to produce (1) an inoffensive residue (2) of reduced bulk, which may be (3) easily dewatered due to reduced water binding properties.

Biological Action

It is important to realize that digestion is dependent upon the presence and growth of a variety of microorganisms, which utilize the food supply or organic matter which is present in the sludge, and that these organisms produce new cells so long as conditions for their growth are favorable and the food supply is undiminished. In the sequel to this discussion * Dr. A. M. Buswell will cover in greater detail some interesting observations in connection with methane producing organisms and their role in sludge digestion.

Practical Control

From the practical viewpoint we may approach the control of the digestion process as a problem of maintaining environmental conditions most favorable to the organisms which must do the work. The major considerations are reviewed herewith.

Maintenance of Proper Digestion Balance

It is important for the operator to exercise care in adding fresh solids and in withdrawing digested sludge, for instance:

1. Sludge additions should be made to each primary digester as frequently as possible or as may be feasible. By adding smaller quantities at more frequent intervals, a more constant food supply is afforded the organisms and a more uniform gas production will be obtained, indicating a more uniform rate of digestion. Such a schedule also fits in well with the operation of clarifiers. Moreover, it results in a sludge of lower moisture content, which is important in connection with the displacement time afforded by the digester, and in minimizing the amount of supernatant liquor to be handled.

2. Sludge withdrawals should be made frequently in small increments to maintain the buffering effect afforded by the best digested solids. A schedule of balanced plant operation favors filling one sludge bed at a time, or withdrawing at an optimum rate to vacuum filters and incinerators based upon an average quantity of digested solids to be handled.

3. In a two-stage digestion system, care must be exercised in transferring material from the primary or active tank to the secondary or concentration-separation tank. The best digested solids of the primary tanks should not be depleted. In studies made on the operation of municipal sludge digestion systems on a solids retention basis, it has been found that of the amount of material transferred, 20 per cent or less by volume of the transfer should be from the best digested sludge at the bottom of the tank, with the balance of the transferred material, or 80 per cent by volume, made up of the best liquor (of lowest solids content) from the upper portions of the tank. By this procedure, for a detention time on a liquid displacement basis of 30 days, the solids that are retained in the digestion system may average as high as 60 days, resulting in greater reduction and compacting.

In connection with digestion installations handling certain industrial wastes, where the major portion of the solids to be digested are in solution, and the entire waste is added to the digestion system, much shorter liquid displacement times are provided. One

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* See page 28.

installation presently in successful operation provides only a 4-day digestion period on a displacement basis. In such a case, with the small amount of suspended solids present, the discussion outlined above in regard to solids retention and transfer would not apply.

Temperature of Tank Contents

It has been generally accepted that the temperature during the process of digestion is of great importance, a temperature of approximately 90° to 95° F. being found by most operators to be optimum as measured by the rate of gas production and quality of the digested sludge, within the feasibility of effective and simple operation. To be most effective, however, the temperature must be uniform throughout the entire depth of the digestion tank and should be maintained within a narrow range of a few degrees above or below an established value. It appears that the organisms depended upon for the digestion of sewage solids are quite sensitive to temperature changes and cannot stand rapid variations without a marked decrease in activity.

A survey of tank inventory records of digesters at a number of plants studied in the past few years has revealed temperatures in the scum zone from 10° to 15° below the temperature maintained in the balance of the tank, a condition which is not conducive to proper digestion of that material.

At one well-operated treatment plant handling a malt house waste, the operator reported a temperature of the digestion tank contents of 95° F. The temperature appeared to be maintained quite close to this value, as recorded at one particular time each day. Sudden reductions in hourly gas production rate were encountered at regular intervals each day, however, which suggested that a check of the temperature of the tank contents immediately after raw solids were added might be in order. It was found that the temperature of the contents of the tank dropped as much as 7° F. due to the cold raw sludge additions, with the deficiency being made up by the average heat added during the period prior to the next solids addition.

Reaction in the Digestion Process

It is normally conceded that the pH of the tank contents should be about 6.8 to 7.2. Ordinarily in a well-designed and operated digestion system, where acid wastes are not present in the material to be treated, it is possible to maintain a balance between fresh and digesting solids so that the reaction will remain within favorable limits. It is the writer's opinion that the proper reaction of the digestion tank contents is the result of proper digestion conditions and, conversely, that conditions for proper digestion are not obtained by mere adjustment of the pH. The almost universal practice of resorting to the use of lime to correct a low pH appears to do more damage than good, and recent experiences of the writer suggest the revolutionary statement that *"lime in any form or amount has no place in a digester."*

This statement was recently confirmed in a rather strong manner in connection with an installation where a critical digestion condition existed. By careful control of the rate of feeding during the starting of the digestion process, a satisfactory action had been obtained in two or three weeks, despite a 6.0 to 6.5 pH which was gradually increasing. On the advice of a state representative who visited the plant a week or so later, and who saw the low pH on the records, lime was added, although the amount would not have appeared to be excessive. This procedure resulted in a complete stoppage of the digestion action, which during the next four weeks could not be revived. It was finally necessary to remove most of the contents of the one digester and to start the tank anew.

In digestion, almost any organic matter goes through a stage of acetic acid formation, which acid is acted upon by methane-producing organisms to form methane and carbon dioxide. The action of lime tends to produce a highly ionized condition causing the reaction to go strongly to the acetate, upon which the bacteria cannot work. The comparison is shown by the following:

$$2(CH_3COOH) + Ca(OH)_2 \leftrightarrows Ca^{+} + 2(CH_3COO)^{-} + 2H_2O$$

while without lime added the acetic acid breaks down as follows:

$$CH_3\ [COO]\ H$$
$$CH_4 + CO_2$$

In installations where the writer has had any part in directing the operating procedures, the taking and recording of pH has been eliminated, and such data have not been missed in the digester control procedures. Volatile acids control has been substituted in its place.

Volatile Acids Control

Volatile acids control has been employed successfully to foretell the approach of retarded digestion conditions at a number of municipal and trade waste installations where digesters are operating at higher loadings than those normally encountered in domestic sewage treatment practice. In fact, to digest most trade wastes successfully it has been found to be absolutely necessary to practice volatile acids control. This involves a simple determination which may easily be made daily to provide a "warning" long before a change of pH, alkalinity, drop in rate of gas production, or "foaming" conditions would indicate that trouble is at hand. This control method is described more completely in an article by the writer entitled "Controlled Digestion," which appeared in the May, 1944 issue of THIS JOURNAL.

In practice, if the volatile acids determination indicates a concentration of, say, 2,000 p.p.m. in a digester sample, or if succeeding determinations indicate a continued rise in the concentration of volatile acids, either of the following steps must be taken: (1) Reduce the loading of raw solids in the digester showing the increase by diverting some of the raw solids to another digester in the system, or (2) Circulate lower volatile acid content material from a second stage digester to the overloaded primary digester. As a result of such circulation a more rapid gasification takes place and the volatile acids are reduced much more than can be accounted for by mere dilution.

Scum

A discussion of sludge digestion is not complete without consideration being given to the question of scum.

The presence of an excessive scum blanket in a digester will greatly reduce the effective digestion capacity and create conditions conducive to foaming or to delayed and violent digestion activity. Some scum may tend to form in any tank receiving raw solids but it should not build up to more than 24 in., and the material should be moist and should not retard the release of gas from the tank.

Suggested methods for the control of scum will be outlined briefly in a summary of practical operation procedures at the end of this discussion.

Foaming

Foaming will generally result from an over-active tank due to "lay-over" of solids which have not started digestion and which all start to digest at one time when the environmental conditions are improved. These conditions frequently obtain when a cold digester full of solids is heated for the first time.

Supernatant

The disposal of supernatant liquor has become of increasing importance as a problem since this material, when discharged from the digester in large volume or high in suspended solids and B.O.D., is exceedingly damaging to the main treatment processes. In a normally operating digester this problem is easily overcome by selecting a supernatant liquor lowest in suspended solids for removal from the digestion system, and withdrawing it at a continuous and slow rate. Until recently there has not been any reliable means of accomplishing this except by the skill and care of the operator in selecting the proper drawoff level. Even with proper selection of the best material the rate of drawoff is generally excessive.

One of the main effects of supernatant liquor as discharged back into the treatment process is that it causes the primary settling tank to become septic. The supernatant liquor, being high in oxygen depletion characteristics and carrying active anaerobic bacteria, will seed the solids in the settling tank, depleting the oxygen and creating conditions conducive to septicity. The upsetting effect of this material is greatly minimized if it is discharged to the secondary treatment units rather than the primary settling tanks.

It will be interesting to watch recent developments in connection with supernatant liquor studies, which show great promise of making use of digester overflow liquor to advantage in connection with secondary treatment processes, by utilizing the nitrogenous material present. One application of this nature has been described by L. S. Kraus in the November, 1945 issue of THIS JOURNAL.

Summary

The accompanying figures show a design of a digester system illustrating an arrangement of piping, pumps and other devices which allow an operator to obtain the utmost in the way of digester control. A brief description of the procedures possible with the practical design as shown will indicate the manner in which the important elements of digester control, as referred to in this discussion, may be achieved.

With reference to Figure 1, which is a plan view taken from the details of an actual installation now being constructed in California, and to the diagrammatic sketch in Figure 2, a circulating pump is provided for the purpose of recirculating digester liquor from a zone above the best digested sludge in the tank, with a discharge point in the center of the tank at the high liquid level. The discharge of this active seeding material onto the scum layer tends to soften the scum and bring it into intimate contact with the active liquor. Liquor should be circulated at a rate which will overturn the upper two-thirds of the tank contents in from 24 to 48 hr.

Maintenance of optimum and uniform temperature throughout the entire tank, especially in the scum zone, is possible by passing the circulated liquor through an external heater and heat exchanger, containing a fire box and fire tubes in which gas or oil is burned, giving up its heat to a water bath which in turn transfers the heat to the liquor or sludge circulated through tubes immersed in the same water bath.

Raw sludge, when added to the system, is pumped into the circulated liquor where it is intimately mixed with the active material as circulated, and is heated to the tank temperature before being discharged into the digester at any of the points as shown. Thus great variations in tank temperatures due to raw sludge additions are avoided.

If unusual heating demands occur, any deficiency in available gas can be overcome by the automatic burning of oil to maintain the heating requirements, thus avoiding any drop in digestion tank temperature. Such lower

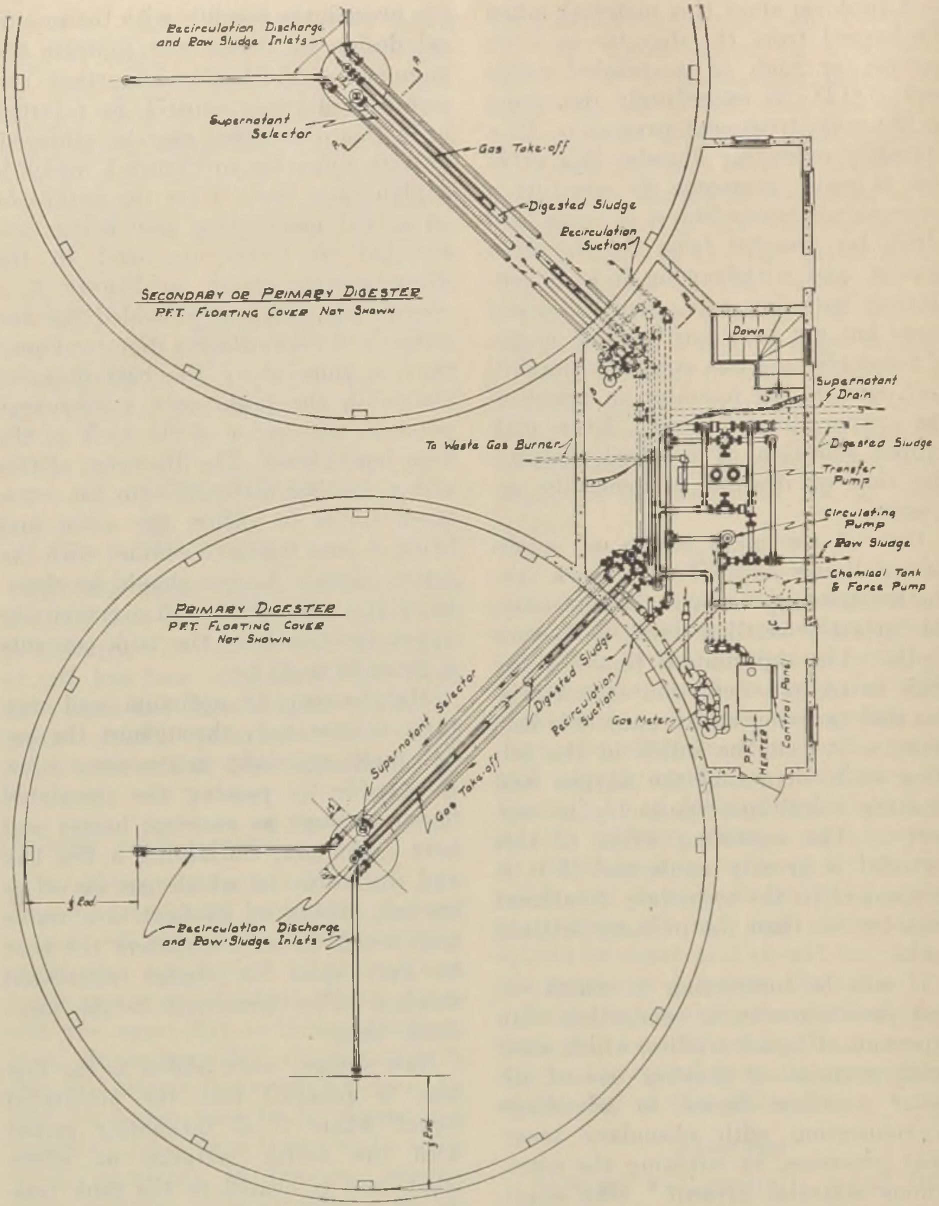

FIGURE 1.—Piping arrangement for practical digester control.

temperatures would be reflected in reduced rates of digestion with a resultant drop in gas production. When the supply of gas is sufficient to satisfy all necessary heating, the auxiliary oil fuel is automatically cut off.

A small chemical mixing tank and force pump, with a discharge connection into the circulated liquor line, makes possible the addition of ammonia nitrogen containing solutions that have been shown to be beneficial in the dispersing of heavy scum layers which do not yield to the liquor circulation alone.

The circulating pump or the transfer

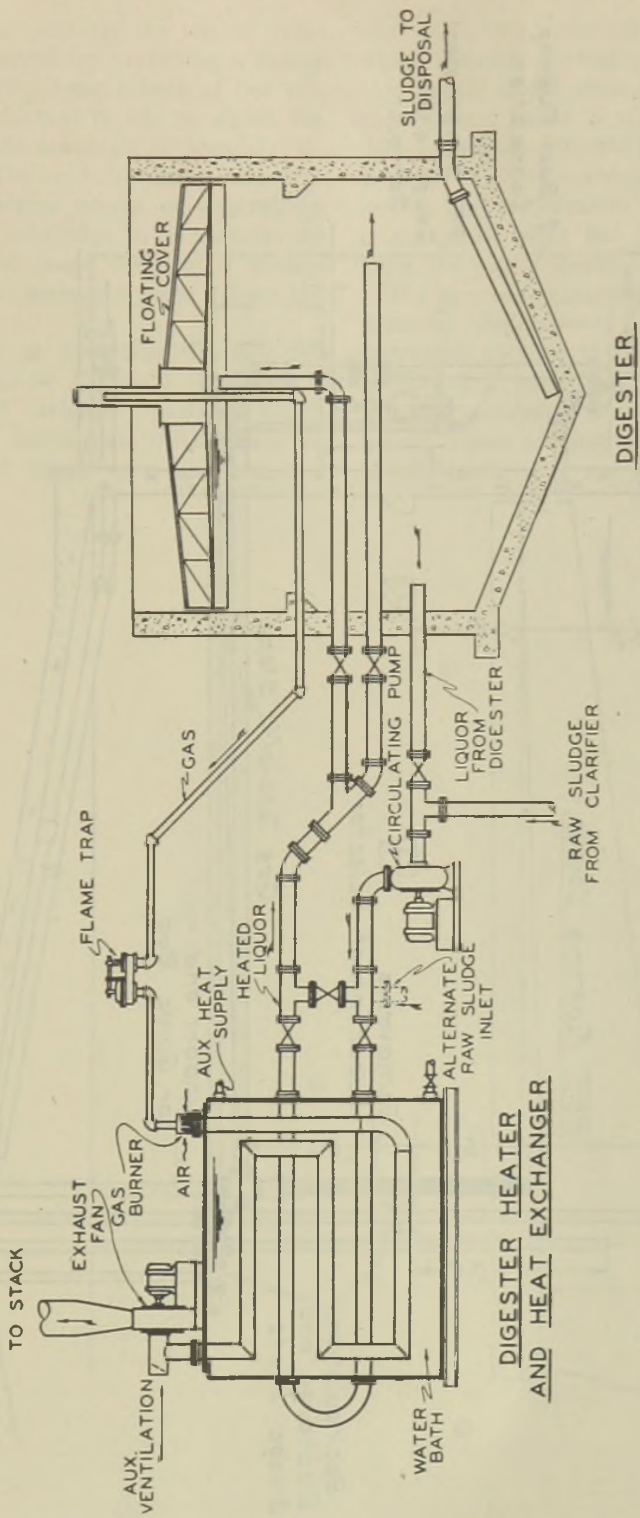

FIGURE 2.—Diagrammatic piping arrangement for circulation and heating of digester liquor and added raw solids.

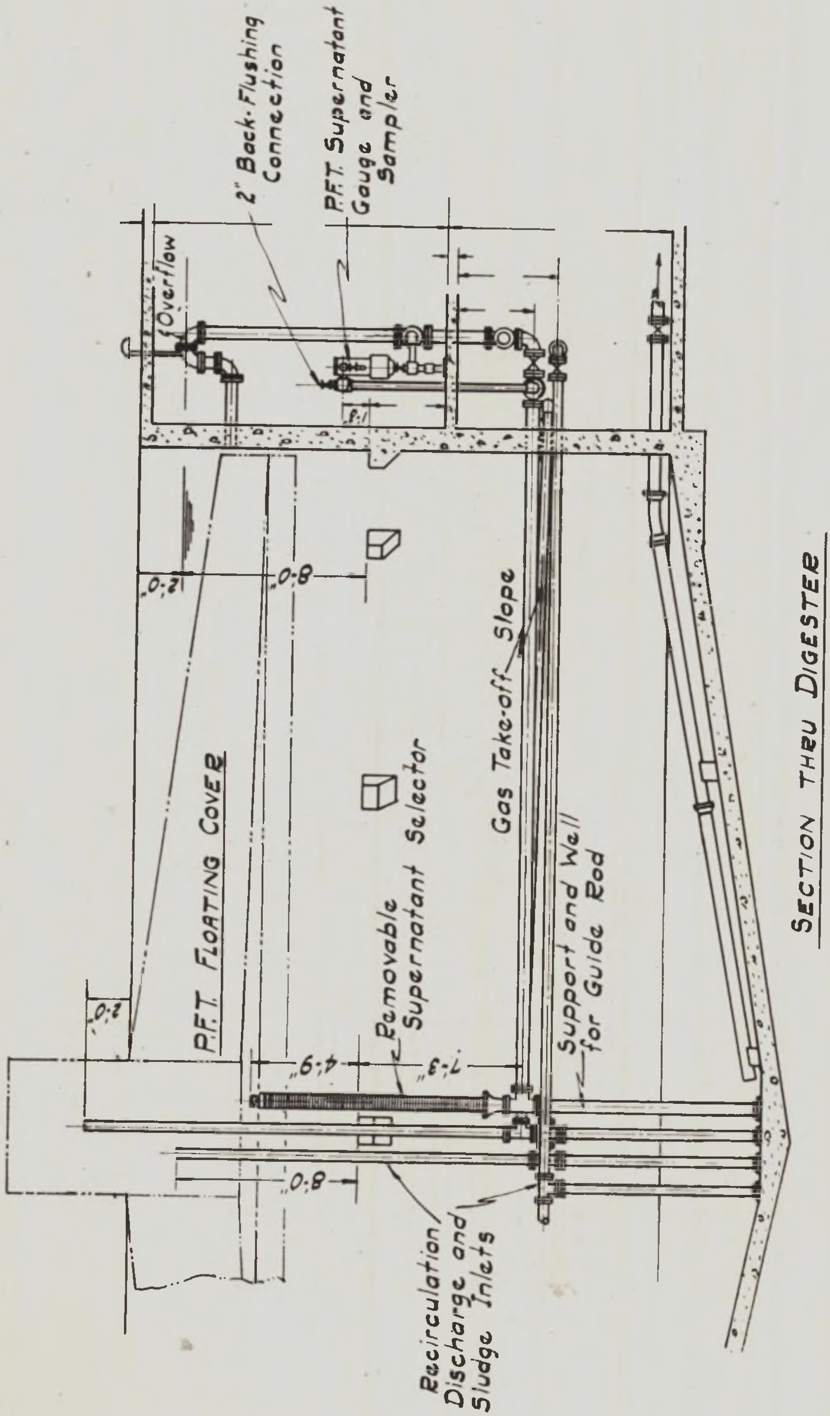

FIGURE 3.—Section of digester showing supernatant selector and gauge.

pump makes possible the use of volatile acids control by providing a means of transferring from a tank of low volatile acids content to one in which the volatile acids are high or steadily increasing. The transfer pump also provides a positive means of controlling the amount of sludge to be transferred from a first stage tank to a second stage tank to maintain proper digestion balance.

Figure 3, as a section through one of the tanks of Figure 1, indicates a supernatant selector system which allows the continuous withdrawal of supernatant liquor at a uniform and slow rate, by employing a slotted tube which extends throughout a considerable depth of the tank contents where supernatant liquor is most likely to be located, and a calibrated gauge control device. With this arrangement the selection and withdrawal of supernatant is automatic with but little attention from the plant operator.

The general piping arrangement also provides the utmost in flexibility of operation so that the raw solids may be added to any tank in the system. The arrangement also allows supernatant liquor heating and recirculation to any tank.

IMPORTANT CONSIDERATIONS IN SLUDGE DIGESTION. PART II.—MICROBIOLOGY AND THEORY OF ANAEROBIC DIGESTION *

By Dr. A. M. Buswell

Chief, Illinois State Water Survey, Urbana, Ill.

In the preceding paper, Mr. Schlenz has given a very clear bird's-eye view of the sludge digestion process, its objects and aims, and the necessary operating facilities required to attain the desired results. It is the purpose of this discussion to consider the chemical and biological reactions which take place in the sludge digestion process. When viewed from this angle, the need for the precautions and devices described by Mr. Schlenz becomes immediately apparent.

Fundamental Considerations

To begin with, let us review briefly a few fundamentals. First, why must sewage be treated? The answer obviously is to prevent pollution of streams, with its resulting nuisance in the way of odors and the spread of disease.

The next question is, what material in sewage produces these objectionable results? The answer is, organic matter, both in the form of bacteria, benign and pathogenic, and unorganized or dead organic matter. Such material is objectionable for four reasons: First, the pathogenic bacteria spread disease; second, the dead organic matter serves as food for bacteria, allowing them to multiply under favorable conditions; third, the organic matter, in decomposing, produces odors; and fourth, the organic matter has a very high chlorine demand so that excessive amounts of this disinfectant are required to kill pathogenic bacteria.

This rather complicated analysis of pollution factors can be greatly simplified if we consider the problem from a purely chemical standpoint. Using chemical symbols merely as shorthand, the problem can be stated in very brief space. For this purpose it will be considered that all organic matter, living and dead, is composed of carbon (C), hydrogen (H), and relatively small amounts of a few other elements which will be represented by X.

The symbol for organic matter, then, is written as CHX. The reaction of this material with sulfate can be written in chemical shorthand as follows: $CHX + SO_4 \rightarrow CO_2 + H_2S$ or RHS (I). In other words, the organic matter results in the reduction of sulfates to form the foul-smelling H_2S, or the even more disagreeable RHS, where R stands for any complex carbon-hydrogen radical.

In order to prevent this reaction carbon and hydrogen must be removed from the polluted liquor. When this has been accomplished the sewage is purified. It will no longer produce nuisance, it will have a low or zero chlorine demand, and there will be no further food for bacterial growth. Sewage purification is simply the removal of carbon-hydrogen compounds.

When reduced to these simple terms, all stabilization processes can be classified under two simple types of reactions, namely, aerobic and anaerobic. The aerobic process can be represented as follows: $CHX + O_2 \rightarrow CO_2 + H_2O + X$ (II). Complete oxidation of the carbon and hydrogen to carbon dioxide

* Presented at 20th Annual Ohio Conference on Sewage Treatment, Akron, Ohio, June 20, 1946.

and water would yield an effluent with zero chlorine demand and zero oxygen demand. This process, of course, will be recognized as the one which occurs in either activated sludge tanks or trickling filters.

The second, or anaerobic process, can be represented by this reaction: $CHX + H_2O \rightarrow CO_2 + CH_4 + X$ (III). This represents the ideal or complete removal of carbon, partly as the completely oxidized carbon dioxide and partly as methane, which, while still unoxidized, is very insoluble and therefore escapes as gas, leaving the liquid purified. This process will be recognized as summarizing what happens in sludge digestion or in the anaerobic fermentation of heavier liquid wastes.

Anaerobic Fermentation

Anaerobic fermentation has long been recognized as the cheapest method of removing organic matter, carbon and hydrogen, from sewage or waste liquors where conditions are suitable for its application. The limit for practical application of anaerobic fermentation appears to be in the range of 1 per cent organic matter or more. This includes the sludge resulting from primary sedimentation. When the concentration is very much below 1 per cent the amount of liquid required to carry the optimum solids loading becomes so great that the economies of the process disappear. The other limit is that digestion ordinarily will not carry the purification beyond 75 per cent.

A specific example of the economy of anaerobic fermentation may be taken from a study of dairy wastes made in the Illinois State Water Survey laboratory some years ago. This study indicated that the cost per pound of carbon and hydrogen removed was about 20 times as great when the aerobic process was used as it was when the anaerobic method was employed. With such a large advantage in cost, the anaerobic process properly deserves the intensive study and consideration which it is now beginning to receive, and henceforth this discussion will be confined to it.

Reaction III, producing CO_2 and CH_4, has been known for many, many years. As a matter of fact, one of the early names for methane was "marsh gas," since an inflammable gas had been recognized in bubbles rising from the mud at the bottom of marshes and shallow ponds. The will-o'-the-wisp sometimes seen at night has been attributed to the ignition of these bubbles of methane as they rise over marshy areas.

Methane as a product of a wide variety of bacterial fermentation processes has also been recognized for many years. A partial list of fermentations yielding methane would include composting of straw, leaves and manure; retting of flax; the decomposition of fertilizer in the soil; the liquefaction of cellulose which causes losses in various textile industries such as paper manufacture, etc.; and the production of various fatty acids from starch, sugars, and cellulose. Methane is produced as one of the early products in spontaneous combustion.

Biology of Anaerobic Fermentation

Although attempts were made to isolate the bacteria responsible for this reaction very early in the history of bacteriology, or some 50 years ago, none was successful in producing actual pure cultures until within the last ten years. Many experimenters, including the writer, had been successful in producing cultures of very high activity, but microscopic examination always revealed a somewhat mixed bacterial growth. About ten years ago it began to be apparent that some five or six different organisms in pure culture were capable of producing methane.

Most experimenters reported two somewhat different rod-shaped forms and two distinctly different spherical or coccus forms. The two coccus forms were distinctly different in size; one was usually seen in groups of 4 or 8, resembling *Sarcina.* These organisms are rather large, being 4 or 5 *mu* in diameter (a red blood corpuscle is 7 *mu* in diameter). The other coccus form is very small, being something less than one micron in diameter, and is referred to as a micrococcus.

The rod forms are rather similar, being rather long and thin and slightly bent. The distinguishing characteristic is a tendency to form long filaments on the part of one of them.

These organisms, in addition to producing methane, also possess the following common characteristics: They are non-motile, non-spore-bearing, and gram-negative. They are obligate anaerobes and are capable of using ammonia as a source of nitrogen. They all develop at a relatively slow rate, requiring several weeks after inoculation for the development of an active culture.

The earliest workers found that many of the organisms could produce CH_4 from ethyl alcohol or calcium acetate. About 1936 Barker, using a medium in which the only source of food was ethyl alcohol, was successful in isolating a pure culture of one of these four types of organisms. This was the *Methano bacterium Omelianski.* Recently in our laboratory we have succeeded in obtaining what appears to be a pure culture of the large *Methano sarcina* form, which is capable of producing methane from calcium acetate.

The isolation of these two pure cultures which are able to produce methane has been a long step forward toward improving anaerobic fermentation. Up until a few years ago it was believed that the process was what is known as "symbiosis," and required the presence of several specific organisms for its success. Since pure cultures of single organisms are able to produce methane, the way is now open for artificially developing active inoculum material which will shorten that long-drawn and nerve-racking period of waiting for digestion to start.

Field Observations

Leaving the laboratory and theoretical research for the time being, it is of interest to turn to some recent observations on plants where anaerobic fermentation is in progress. The plant of the Standard Brands Company at Pekin, Ill. designed by Metcalf and Eddy with the writer's collaboration, was put into operation in 1941 and was inoculated with both solid and liquid sludge from the sewage treatment plant of the Peoria Sanitary District. Fermentation started promptly and proceeded satisfactorily without interruption. At the end of about a two-year period, however, the rate of fermentation began to fall off and the volatile acids reached a rather high value of something over 2,000 p.p.m. Inoculation with sludge from the Peoria plant brought the tanks back into normal activity. Again, at the end of another two-year period, the activity began to drop off and reinoculation was again tried with success similar to that which had been used formerly. This plant, incidentally, is treating the waste from a yeast manufacturing process at a loading of about 10 times that ordinarily used in municipal sewage sludge digestion.

Another plant on which recent observations have been made is that installed at Jefferson Junction, Wis., for treating wastes from malt manufacture. Actually the feed to the digester consists of the sludge which unloads from a trickling filter. This plant started out satisfactorily but the digestion process was practically disrupted as the result of lime treatment. It was brought back to good operation by application of the controlled digestion routine.

Relation of Bacterial Flora to Operation

The relation of bacterial flora to successful operation is well illustrated

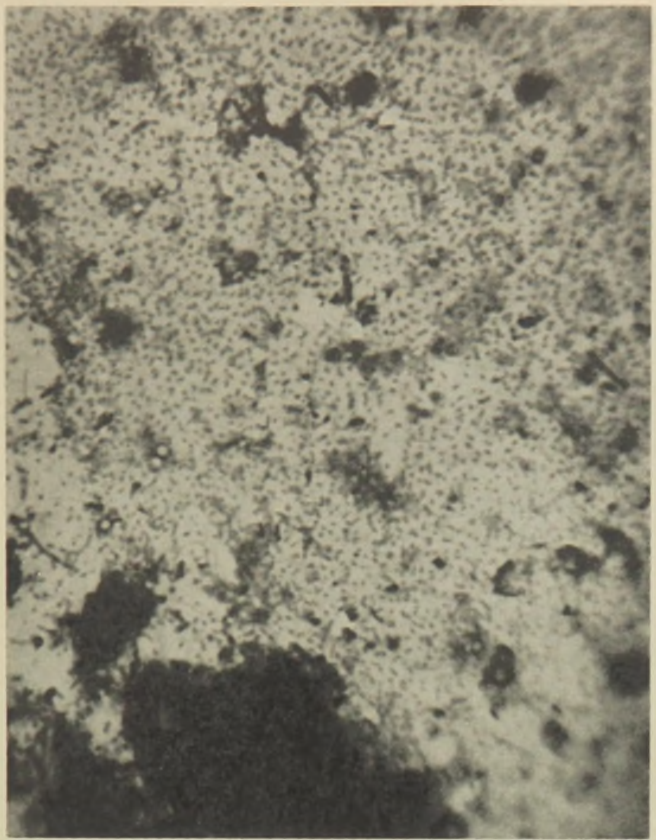

FIGURE 1.—Culture showing numerous micrococcus forms (gas production up).

by Figure 1. This sample was taken a little over a year after the plant had been in successful operation and when it was producing gas at a very high rate. It will be noticed that this slide shows a very nearly pure culture of Micrococci, one of the organisms observed previously by practically all workers in methane-producing fermentations.

Unfortunately, a comparative slide at the time of poor operation of this plant is not available to compare with the one shown. Figures 2 and 3, however, made from contents of a fermentation tank at Crystal Lake, Ill., reflect operating conditions very strikingly.

Figure 2 shows relatively few organisms and no particular predominance of any one methane-producing form. At the time this sample was taken the fermentation was very slow, producing only about 100 cu. ft. per hr.

Figure 3 shows a luxuriant growth of typical methane-producing organisms, particularly the Micrococci, some of the rods, and some of the large *Sarcina*. Careful control of temperature, feed rate and circulation had increased the gas yield to about 1,000 cu. ft. per hr.

Figure 4 shows a greatly enriched culture grown in laboratory flasks with calcium acetate as a source of food. This slide shows a large number of the large *Sarcina* forms and a considerable number of the small Micrococci. The long threads are asbestos fibers which are added to the culture to provide the

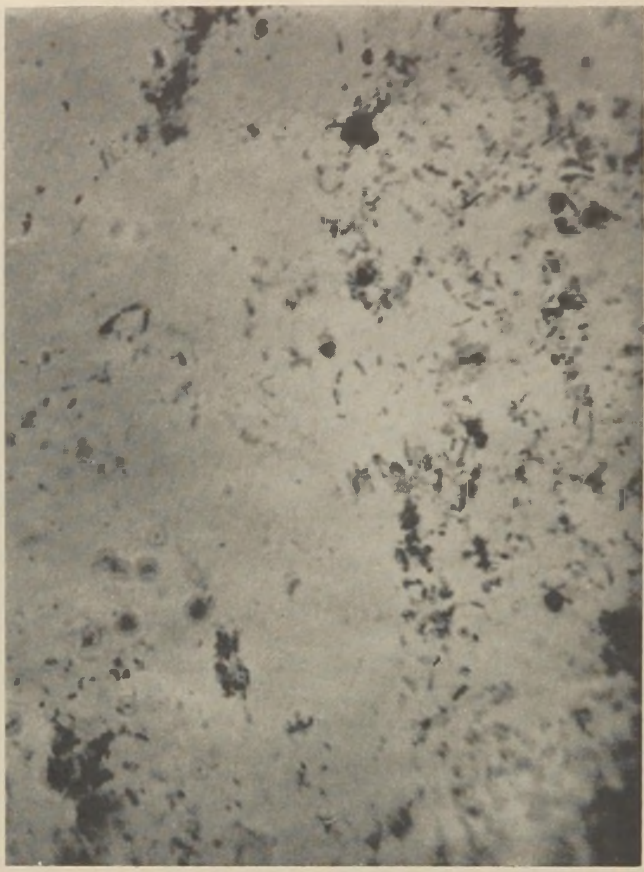

FIGURE 2.—Culture—Crystal Lake. Gas production down. Culture very atypical, not indicative of a good fermentation.

mechanical support which has been found necessary for successful rapid growth.

Figure 5 shows a purified culture of this large *Sarcina* form which was isolated by a large number of successive dilutions from the culture shown in Figure 4, followed by transfer to agar in small anaerobic culture tubes. The material shown in Figure 5 was fished from an isolated colony in agar.

These bacteriological observations open up the possibility of the control of the digestion process in a manner approaching that used in other fermentation industries. This is a goal which some 15 or 20 years ago had seemed utterly unattainable. It would now appear quite feasible to prepare cultures in large quantities which would carry a sufficient number of the proper organisms so that a reasonable amount of inoculum would insure rapid digestion in a new tank or in an old tank which is operating unfavorably.

Control of Methane Fermentation

High yields, uniformity of products, and successful inoculation and cultivation are dependent on four conditions:

Large Surface. First, the organisms seem to require a certain amount of surface for their propagation. When

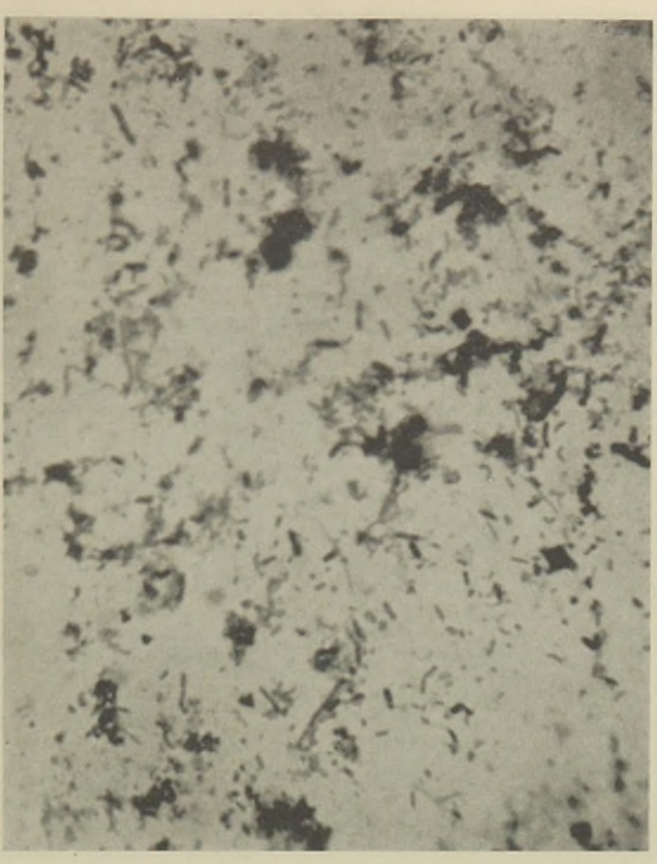

FIGURE 3.—Culture—Crystal Lake, showing rod forms, some Sarcina packets and coccus forms. Generally more abundant microflora than Figure 2. Increase in gas production observed at time this slide made.

material of a fibrous or granular nature is fermented, this requirement is satisfied by grinding or shredding the substrate, but when dissolved substrates are employed, some sort of inert surface must be supplied. Twenty-five grams of shredded washed asbestos per liter is satisfactory. Fischer, Lieske, and Winzer have found ferric hydroxide or ferrous sulfide useful for the same purpose. With this technique a large number of soluble substances have been used as substrates and over considerable periods of time. Successful inoculation can be made by transferring single fibers of asbestos from an active culture to a flask or test tube containing sterile asbestos and culture media.

Volatile Acids. The second condition is that the volatile acids, which are intermediates in the decomposition of higher compounds, must not exceed a predetermined value, usually from 2,000 to 3,000 p.p.m. (calculated as acetic).

If the volatile acid value is allowed to rise much above 2,000 p.p.m. (as acetic) gas formation drops off, the acids increase rapidly, and usually within 24 to 48 hours all fermentation has ceased.

This factor is followed by making daily determinations of the volatile acids by the method of Duclaux, after acidification of the sample with phosphoric or sulfuric acid. This procedure gives a value which includes

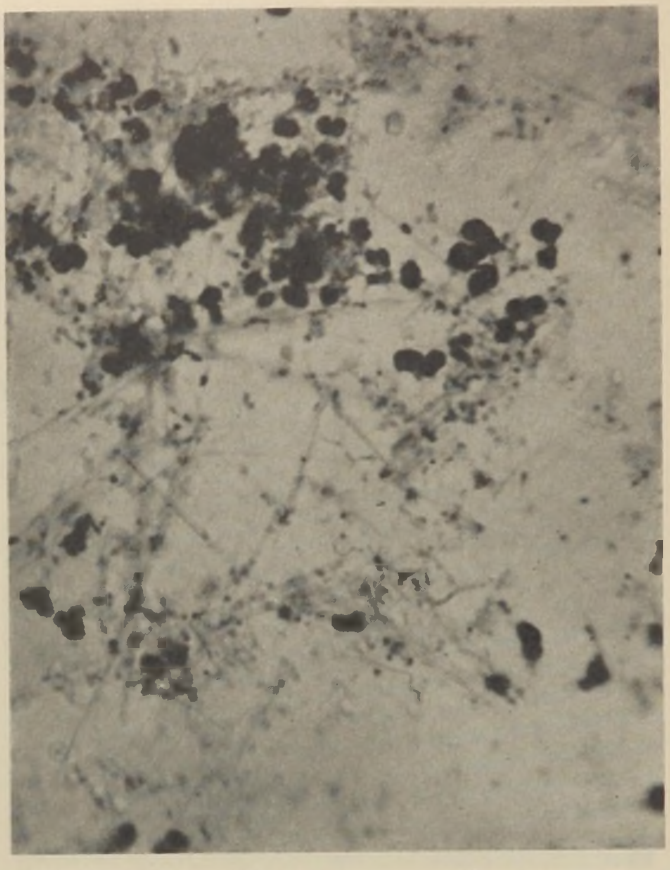

FIGURE 4.—Culture from calcium acetate fermentation, showing large Sarcina packets.

both the free acids and their salts and is independent of the pH value. It is somewhat surprising to encounter such a situation, especially since we have come to think of pH as an almost all-important factor in fermentation control. Since it is the total of acid plus its salt which controls the fermentation, the addition of alkali is of little use. In fact, the production of acid is stimulated in some cases by the addition of lime.

There is only one way to limit the accumulation of volatile acids. That is to limit the rate at which the substrate is added to the fermentation vessel, so that the acids will be fermented to CH_4 and CO_2 as rapidly as they are formed from the raw substrate. Many of the early failures are due to the "batch" type of fermentation in which too much substrate was present.

If a culture has developed too much acid the only remedy is dilution. This has been adapted to a series of stage digestion for certain industrial wastes.

Scum. A third condition which must be avoided is the formation of any considerable amount of scum. This is sometimes encountered when fermenting greasy material. The objection to scum is that it constitutes a zone of high substrate concentration in which a high concentration of acids is likely to develop. In laboratory fermentations, this can be avoided by breaking up the scum mechanically. In plant scale fermentations, the power required for a scum breaker is too great. Moist-

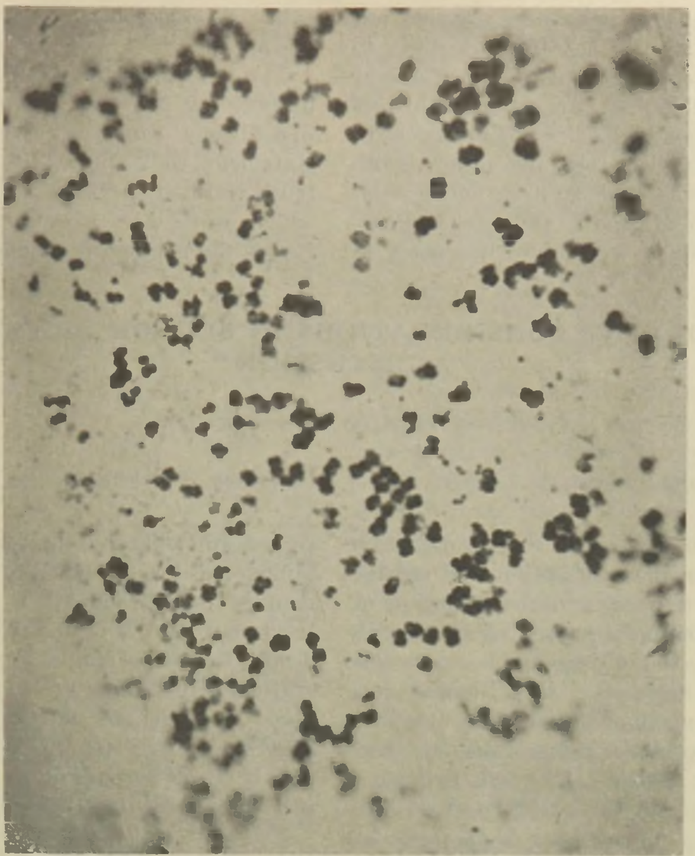

FIGURE 5.—Purified culture of Methano sarcina.

ening the scum with liquid pumped from beneath it is a very effective and inexpensive remedy.

Fibrous Material. A fourth difficulty is encountered with fibrous material such as paper, shredded cornstalks, etc. These substances form a tough mat at the top of the fermentation vessel. The objection to this mat is, as above, that it favors the accumulation of large amounts of acid. A mat cannot be broken up mechanically nor by the circulation of liquor with any success. It is necessary to provide the fermentation vessel with suitable connections so that it can be operated alternately in an upright and an inverted position. In this manner, the mat is broken up by the fermentative action itself after each inversion. A fermenter containing a slowly rotating drum has been developed for large scale operation.

Liming

Since so much has been written concerning the advantage or disadvantage of liming digestion tanks, we wish to emphasize our viewpoint on this matter. As Mr. Schlenz pointed out, our experience has been that such a practice is to be avoided.

One of the characteristics of the organisms which produce methane is that they also produce acetic, propionic, and butyric acids under favorable conditions. Because these acids have high commercial value, many attempts have been made to favor or direct the fermentation toward acid production. In our laboratory extensive experiments along this line have been carried out and at times it has been possible to build up acid concentrations of better than 7,000 p.p.m. In order to do this alkali was added, either lime or sodium hydroxide. On the other hand, when it was desired to produce complete fermentation to methane and carbon dioxide it was found necessary to avoid the presence of a large concentration of alkali, such as lime or soda.

The laboratory research from a large number of different laboratories and institutions confirms Mr. Schlenz's statement that the addition of alkali tends to favor the formation of volatile acids, while the avoidance of alkali favors the production of methane.

IMPORTANT CONSIDERATIONS IN SLUDGE DIGESTION—A DISCUSSION *

By M. W. Tatlock

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Any discussion of sludge digestion is based on the assumption that sewage has been treated, and the pollution of streams has been prevented by the removal of the objectionable materials from the sewage. Dr. Buswell has pointed out that the chemist classifies these materials as organic matter, composed of carbon (C) and hydrogen (H), which in the presence of sulfate produces foul-smelling H_2S, and he says that we have purified sewage whenever we have removed the carbon-hydrogen compounds from the polluted liquor. If this is done aerobically the chief end products are CO_2 and H_2O, but if the anaerobic process is used the end products are CO_2 and CH_4. The latter type of fermentation has long been recognized as the cheapest method of removing carbon and hydrogen, since it is readily applicable to all ranges of organic matter over 1 per cent concentration. The upper limit of its successful application is a maximum of only 75 per cent purification.

Sludge digestion has been an integral part of sewage treatment processes for many years, but there are to date no uniform practices of design and operation. The digesters are too often designed and operated simply as holding tanks or as "catch-alls" to use in some manner to aid the other processes of treatment and sludge drying. If the destruction of organics is poor the operational difficulties are too often diagnosed as "lack of capacity" and the suggested correction is "build more." The best answer might often be "correct the operational procedures."

The past war has brought to attention digestion conditions previously thought to be impossible. Municipal installations have handled their wartime loads because lack of construction materials made impossible the addition of more digester capacity. Military installations, if measured by so-called standard practices, often had to take more than the designed load from their first day of operation. Somehow they were successfully operated because the job had to be done. The result has been that we have learned that even sludge digesters will do more than was ever expected of them if they are treated right, *i.e.*, if they are intelligently operated.

The writer has recently returned from military service in Europe where the Germans really practiced sludge digestion because the operation of motor vehicles was only possible by the use of fuel (methane gas) produced in

* Presented at 20th Annual Ohio Conference on Sewage Treatment, Akron, Ohio, June 20, 1946.

the sewage sludge digesters. Necessity produced good design and operation. Since returning to private practice the writer has had supervision of the operation of a plant treating a highly concentrated waste from the manufacture of yeast. The total daily flow of 135,000 gal. is treated by passage through both the anaerobic and aerobic processes to reduce the waste organic matter into the unobjectionable end products of H_2O, CO_2 and CH_4. The two stage anaerobic digesters, with a detention period of approximately two days in each stage, reduce the initial 5-day B.O.D. from approximately 5,000 to 1,100 p.p.m.; and the aerobic filter, operated at a high rate with recirculation and accompanied by settling, chlorination, and dilution with condenser water, gives a final effluent of less than 25 p.p.m. It is significant to note that the original digestion culture, from which Dr. Buswell has isolated methane producing organisms, came from this plant.

The writer's experience emphasizes the following factors as being of significance in the maintenance of proper environmental conditions for the organisms which do the work in a digester:

(1) Too much attention cannot be given to the addition of fresh food and to the withdrawal of the spent or digested residue. If two-stage digestion is employed, then special attention must be given to the transfer of materials from one tank to the other in order to maintain optimum working conditions.

(2) It has long been recognized that the rate of digestion is a function of the temperature of the sludge, but it is necessary to do more than determine the optimum operating temperature. The design must provide not only the means of heating the digesting mass to this temperature but must insure that this temperature is uniform throughout the entire mass. The proper temperature should be maintained within a range of one degree.

(3) Reaction or pH control by the addition of lime has been a common practice resorted to after a change in pH, a drop in the rate of gas production, or "foaming" conditions have indicated that troubles were at hand. A physician does not cure an acid stomach by prescribing soda, he gives hydrochloric acid in order to keep the stomach from secreting too much acid. The same organisms which produce methane also produce acids under favorable conditions, and when acid production from a fermentation process has been attempted, an alkali, either lime or sodium hydroxide, is usually added. There is much proof that the addition of lime is to be avoided if maximum methane production is desirable.

It is a well established fact that the digestion of organic matter goes through a stage of acetic acid formation, which in turn is acted upon by methane producing organisms to form methane and carbon dioxide. A determination of volatile acids calculated to acetic acid will foretell the approach of retarded digestion, or serve as a "warning" long before the usual digestion difficulties indicate that trouble is at hand. The test is simple and is quickly made. Digestion progresses best at volatile acid values below 2,000 p.p.m.; control of the rate of feeding will prevent too rapid increase of the acid content, and if it goes too high it may be reduced quickly by dilution of the tank contents. The use of this test is recommended for good digestion control.

(4) Scum and supernatant liquor have always been subjects for much discussion in connection with sludge digestion. The former need not be a worrisome problem if the scum layer is kept soft and in intimate contact with the active seeded materials in the tank, but the successful handling of supernatant liquor has more complications. Too often the volume, the suspended solids, and the 5-day B.O.D.

are so high that discharge back into the plant badly damages the treatment processes. The best procedure involves a continuous, slow withdrawal of the liquor with the lowest suspended solids. German practice is to pass digester supernatant through a roughing filter before its discharge into the treatment processes. L. S. Kraus, at Peoria, has advantageously used the nitrogenous material present in this material in secondary treatment processes and the writer knows of some additional developments in this direction which may be reported soon.

Mr. Schlenz concluded his paper with a summary which described "design and operation to obtain desired digestion control." The yeast waste treatment plant which was previously referred to as being operated by the writer, employs these items of design and they do make "controlled operation" a reality instead of a theory. Hourly records of feed of raw waste, of temperature, and of gas production give a graphic picture of the very close relationship between the three, and especially demonstrate the need for very close temperature control if optimum gas production is to be expected. Continuous circulation of the upper two-thirds of the digester contents through the heat exchanger gives the desired uniform temperature, which by actual test shows only one-half degree variation between the bottom sludge cone and the top layers of the tank. The volatile acid test, done daily, gives a positive and immediate picture of the conditions under which digestion is progressing, and if adjustment is necessary the primary digester contents are diluted by lower volatile acid content material pumped from the secondary unit.

THE DIGESTION OF SEWAGE SLUDGE CONTAINING VARIOUS CONCENTRATIONS OF SOLIDS

By C. E. Keefer

Bureau of Sewers, Baltimore, Md.

In the operation of sludge digestion tanks attempts are often made to concentrate the inflowing raw solids. This practice conserves sludge gas where tanks are heated and makes available more space for the digestion of sewage solids. It is doubtful, however, if the average solid content in digestion tanks exceeds 10 per cent. In view of these facts it was considered desirable to investigate the extent to which partially dewatered sludge digested. If the moisture content of raw sludge were reduced from 95 to 70 per cent, the dewatered material would occupy one-sixth its original volume. Should this dewatered material digest rapidly, a considerable saving in digester volume would result.

Experimental Procedure

Raw sludge was obtained from the mechanically cleaned primary sedimentation tanks at the Back River sewage works, and digested material was drawn from a small-scale laboratory digester. As indicated in Table I, the raw sludge contained 85.54 per cent volatile matter and had a pH of 5.4, and the digested material contained 57.08 per cent volatile matter and had a pH of 7.5.

The two materials were mixed in the ratio of two parts by weight of raw volatile solids to one part by weight of digested volatile material. The mixture was divided into five equal portions, each weighing 20.42 lb. To each of four of the portions, 225 ml. of a 10 per cent ferric chloride solution was added to coagulate the solids. Three of the portions were then dewatered on a Buchner funnel.

These sludges, Nos. 1, 2, and 3 (Table II) contained the following moistures: 67.53, 74.99, and 85.08 per cent, respectively. The above-mentioned volume of ferric chloride was also added to sludge No. 4, one of the controls, which was not dewatered. Sludge No. 5, to which ferric chloride was not added and which was not dewatered, also served as a control. Lime was added to each of the mixtures to raise the pH to 6.7. Each mixture was then placed in a 5-gal. carboy and incubated at 37° C. The volumes and the analyses of the gas produced were determined at regular intervals. The gas was passed through calcium chloride so that any moisture entrained therein could be caught and subsequently weighed. At the end of the experiment the volatile and the solid contents of the sludges were determined.

Discussion of Results

Sludge No. 1, the moisture content of which was 67.53 per cent at the beginning of the experiment, digested less than any of the other materials. During the 73-day digestion period the volatile solids on the dry basis were reduced from 72.10 to 65.82 per cent. The loss in weight of volatile solids amounted to 64.9 grams, or 29.9 per

TABLE I.—Analyses of Raw and Digested Sludges Used in Experiment

Material	Quantity Used (lb.)	Dry Solids (%)	Volatile Matter, Dry Basis (%)	pH
Raw sludge......	12.42	4.93	85.54	5.4
Digested sludge...	8.00	5.73	57.08	7.5

TABLE II.—Analyses of Sludge Mixtures at Beginning and End of Test

Sludge No.	At Beginning						Gas Production		At End						Loss of Volatile Solids		Gain or Loss of Moisture (gr.)
	Volatile Solids		Fixed Solids		Moisture				Volatile Solids		Fixed Solids		Moisture				
	Dry Basis (%)	Weight (gr.)	Dry Basis (%)	Weight (gr.)	Per Cent	Weight (gr.)	Ml. per Gram of Fresh Volatile Solids	Weight (gr.)	Dry Basis (%)	Weight (gr.)	Dry Basis (%)	Weight (gr.)	Per Cent	Weight[1] (gr.)	Grams	Per Cent (based on fresh solids)	
1	72.10	325.2	27.90	125.8	67.53	938	223.9	61.1	65.82	260.3	34.18	135.2	70.18	933	64.9	29.9	−5
2	71.57	324.8	28.43	129.0	74.99	1361	616.6	149.6	58.16	192.6	41.84	138.6	80.03	1334	132.2	61.0	−27
3	71.79	340.1	28.21	133.7	85.08	2701	10.12	3.19	55.44	174.8	44.56	140.5	90.03	2857	165.3	72.7	+156
4	71.69	343.0	28.31	135.5	94.73	8593	564.8	140.9	59.53	180.5	40.47	122.7	96.60	8628	162.5	71.0	+35
5	72.04	338.4	27.96	131.4	94.82	8602	756.9	183.6	56.78	162.1	43.22	123.6	96.78	8603	176.3	78.3	+1

Note: $FeCl_3$ added to all materials except sludge No. 5.

[1] Includes weight of water that escaped from bottles and was absorbed by calcium chloride.

cent of the original raw volatile solids. The gas produced amounted to 223.9 ml. per gram of fresh volatile solids and weighed 61.1 grams.

Sludge No. 2, which had a moisture content of 74.99 per cent, digested quite well. The volatile solids were reduced from 71.57 to 58.16 per cent, with a loss in weight of 132.2 grams. This sludge produced 616.6 ml. of gas per gram of fresh volatile solids, which amount was greater than that from any of the other materials except sludge No. 5.

Sludge No. 3, the moisture content of which was 85.08 per cent, lost 165.3 grams of volatile solids with a reduction of 72.7 per cent of the raw volatile solids. This reduction was accompanied by an unusually low gas production of 10.12 ml. per gram of fresh volatile solids. On the other hand, there was a gain of 156 grams in the moisture content, indicating a considerable liquefaction of solids.

Sludge No. 4 contained 94.73 per cent moisture at the beginning of the experiment. The loss in volatile solids amounted to 162.5 grams. This loss was accompanied by a production of 564.8 ml. of gas per gram of fresh volatile solids; this gas weighed 140.9 grams. There was also an increase of 35 grams in the moisture content, which indicated some liquefaction of solids.

Sludge No. 5, the only one to which ferric chloride was not added contained 94.82 per cent moisture. This sludge produced 756.9 ml. of gas per gram of fresh volatile solids. The gas weighed 183.6 grams; the corresponding loss in volatile matter was 176.3 grams.

The experiments indicate the possibility of digesting raw sludge that has been dewatered and properly seeded. This method of treatment as compared with the more usual one of digesting sludge prior to dewatering presents certain disadvantages. A larger vacuum filter installation would be required, as more material would be handled

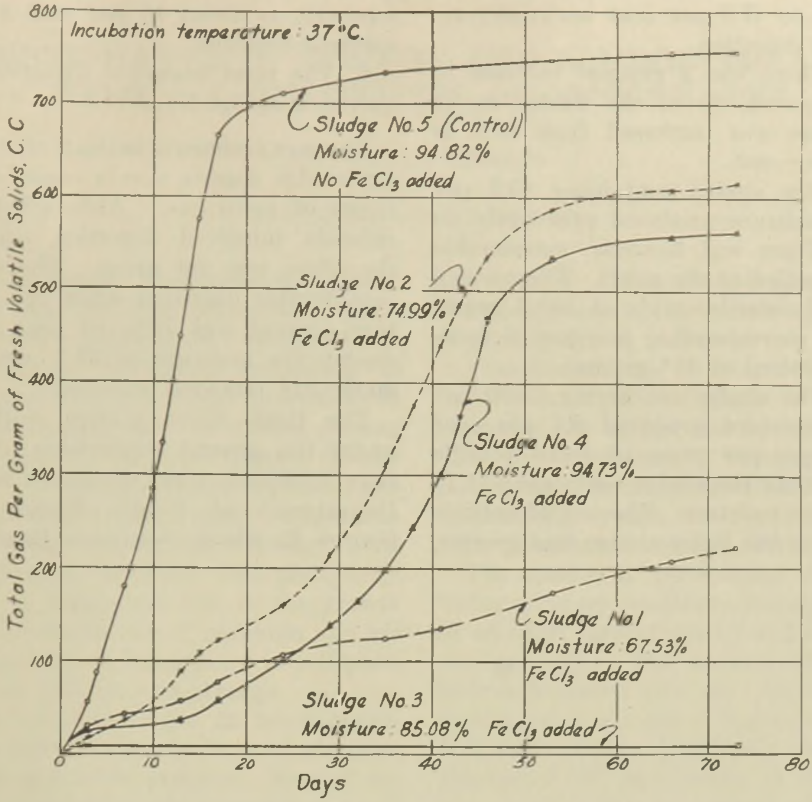

FIGURE 1.—Total gas production from sludge containing various quantities of water.

and the cake output per unit area of filter would be less. Moreover, more coagulant would be needed. On the other hand, there would be a great reduction in digestion space. Reducing the moisture content of sludge from 95 to 75 per cent, for example, decreases it to one-fifth its original volume.

A material reduction in the amount of gas to heat the sludge would also result. Getting the thickened sludge into and out of digestion tanks would present new problems. At the present time most sludge pumps handle materials containing 90 per cent or more of moisture. There are pumps, however, such as those used to pump concrete, that can handle much more concentrated materials. New ways of removing the thickened sludge from digestion tanks would have to be devised. Digesting sludge after it had been filtered would in all probability solve both the scum problem in digesters and the problem of disposal of supernatant liquor.

It is a long step from experimenting with small quantities of sludge in bottles and investigating the problem in a full-size plant. The results are of sufficient interest, however, to warrant a continued study of the problem on a larger scale.

Conclusions

The following conclusions may be drawn from the results obtained:

1. Gas production was less from sludges to which ferric chloride was added.

2. Reducing the moisture content of

sludge to 67.5 per cent materially retarded digestion.

3. There was a gradual increase in the digestibility of the sludge as its moisture was increased from 67.5 to 85.1 per cent.

4. The sludge containing 85.1 per cent moisture produced practically no gas. There was, however, considerable liquefaction of the solids. There was a loss of volatile solids of 165.3 grams and a corresponding increase in moisture content of 156 grams.

5. The sludge containing 74.99 per cent moisture produced 8.4 per cent more gas per gram of fresh volatile solids than the sludge containing 94.73 per cent moisture. The loss of volatile solids in the latter sludge was greater, however, as about 10 per cent of the material liquefied.

6. The most complete digestion occurred in sludge No. 5.

These experiments indicate that sewage sludge digests over a considerable range of moistures. Although ferric chloride inhibited digestion slightly, the effect was not great. There was considerable digestion when the moisture content was 75.0 per cent. Reducing the moisture to 67.5 per cent materially retarded digestion.

The Back River sewage works is under the general supervision of Nathan L. Smith, Chief Engineer of the Department of Public Works, and George E. Finck, Sewerage Engineer.

PHOSPHATES IN SEWAGE AND SLUDGE TREATMENT.* I. QUANTITIES OF PHOSPHATES

By Willem Rudolfs

Chief, Department of Sanitation

Little specific knowledge is available regarding the role phosphorus plays in sewage purification. There are a number of references pertaining to phosphates as a fertilizer ingredient in sewage and sludge but studies dealing with the effects of phosphates on oxidation of sewage, sludge digestion, settling, coagulation, sludge expansion and sludge drying are wanting. It is well-known, however, that phosphates play an important role in the growth and multiplication of plankton and are presumably of importance in self-purification processes in streams.

Phosphorus occurs in micro-organisms primarily in the form of phospholipids and nucleoproteins. Most of the organic phosphorus compounds are very susceptible to decomposition by bacteria and are conceivably of importance in the stabilization of sewage sludge or other organic wastes. According to Sverdrup, Johnson and Fleming (1) utilization of phosphate and nitrate by plankton proceeds at a parallel rate. There appears to be a definite relation between organic nitrogen and organic phosphorus.

The Phosphorus Cycle

The phosphorus cycle is relatively simple as compared with the cycles of nitrogen, sulfur and carbon. The plants utilize phosphate-P, which they convert into organic phosphorus compounds. Animals depend upon plants for their phosphorus requirements. Bacteria regenerate the phosphate from the remains of animals and plants and the phosphates again become available to plants, closing the cycle.

Phosphorus may be stored in bacterial cells, in parts of plants or certain organs of the animal and human body. The old expression "without phosphorus man in incapable of thinking" undoubtedly refers to the relatively high phosphorus content of the brain.

The amount of phosphorus ingested under ordinary conditions through food by an adult varies from 1.2 to 2.0 grams per day (2). The amount of phosphorus excreted per day depends, in part, upon the amount ingested but is still more closely dependent upon the absorption of phosphates in the human body. The proportion of phosphorus discharged in relation to the intake is highly variable and depends on diet and health of the individual.

In human beings from 50 to 65 per cent of the phosphorus discharged is found in urine and from 35 to 50 per cent in feces. The phosphorus found in urine is in the oxidized form of orthophosphoric acid. It is present as disodium and monosodium phosphate and as free phosphoric acid. The relative proportions of these substances depend upon the character of the diet. Urine from a heavy meat diet is acid and contains more free phosphoric acid and the monosodium salt, whereas in urine from a vegetable diet the proportion of disodium phosphate is larger.

Phosphates in Sewage

The phosphates present in domestic sewage are primarily derived from urine and feces, with smaller quantities contributed by vegetable and meat

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

residues from the kitchen and by cleaning compounds.

Analyses of twelve domestic raw sewages, settling tank effluents and trickling filter effluents showed the following ranges and averages, expressed as p.p.m. P_2O_5:

	Range	Ave.
Raw sewage	4.0–9.2	5.2
Settled sewage	2.0–5.0	3.5
Filter effluent	0.2–1.8	0.5

Calculation of the grams of phosphoric acid (P_2O_5) per person on the basis of 100 gal. per capita daily of sewage production shows a variation of from 1.5 to 3.4 grams.

Since the number of available analyses is rather small, it is difficult to present the average phosphoric acid content of American sewage. The quantities present will vary primarily with the amounts of trade waste present, particularly organic animal wastes such as slaughterhouse wastes, containing fat-like substances—lipoids—which play an important role in animal nutrition. Among the prominent lipoids are the phospholipids. Other organic wastes such as milk wastes contain milk salts high in phosphates. The majority of analyses for domestic sewage show a variation between 2.0 and 3.8 grams per capita. Veatch (3), discussing the use of sewage effluents in agriculture, gives the quantities of phosphoric acid in untreated municipal sewage as ranging from 5 to 8 p.p.m., with an approximate average of 6 p.p.m. If a sewage discharge of 100 gal. per capita daily is assumed the quantities of P_2O_5 would range from 1.9 to 3.0 grams per capita with an approximate average of 2.2 grams. Folwell (4) gives, as an average daily production of P_2O_5, 0.015 lb. per capita or about 6.8 grams per capita per day. The figures given by Veatch and our own analyses are in fairly good accord for American sewages.

An early record of sewage composition by Letheby (5), showing the results of analyses of sewage discharged at all hours and at all seasons from 10 outfalls of London city sewers, gives the total phosphoric acid content as 4.3 grams per capita, with 2.1 grams dissolved and 2.2 grams per capita as suspended P_2O_5. Figures available for other English sewages show a range of 1.9 to 4.8 grams per capita.

Stroganoff (6), reporting the composition of sewage in Moscow, shows yearly variations of 1.4 to 2.0 grams of phosphates (P_2O_5) per capita per day, with an average over a 5-year period of 1.8 grams. He points out that variations were caused by differences in food supplies due to war, revolution, and famine; but that the quantities of P_2O_5 discharged are rather constant. He suggested that in peace time the average P_2O_5 would be close to 1.5 grams per capita.

Kreutz (7), discussing primarily the utilization of sewage sludge and basing his statement on limited information, asserts that the phosphoric acid content of sewage in Germany averages 20 grams per cubic meter or 2.0 grams per capita per day. Geissler (8) states that the sewage of Hannover contained 3 grams of P_2O_5, 11 grams of N and 7 grams of K_2O per capita; whereas Keppner (9) calculates a content of 1.9 grams P_2O_5 per capita per day, on the basis of an annual sewage flow of 28,250 m.g. produced by 246,000 persons in Munchen.

The quantities of phosphates discharged vary materially during the day and change with the strength of the sewage. A good example is given by Hahn and Langbein (10) for the sewage in Berlin:

Time	Total Solids (p.p.m.)	Susp. Solids (p.p.m.)	N (p.p.m.)	P_2O_5 (p.p.m.)	P_2O_5 (gm./cap.)
10 A.M.	1,677	382	148.6	34.0	5.3
3 P.M.	1,445	258	73.6	19.2	2.9
3 A.M.	910	39	42.0	7.9	1.2
Ave.	1,550	340	109.0	20.6	3.2

The P_2O_5 in grams per capita was calculated from the average flow, which amounted to 157 liters per capita per day. The average per capita value is materially higher than the average for sewage in Germany given by Kreutz (7). As might be expected, the ranges for P_2O_5 of American, English and German sewages are rather close, with averages between 2.0 and 3.0 grams per capita. Of interest is that the reported discharges per person vary between 1.4 and 2.0 grams, which is considerably lower than the quantities found in sewage.

Phosphorus in Sewage Effluents

The literature pertaining to the removal of phosphoric acid by sewage treatment is limited. Rideal (11) found 3 p.p.m. phosphate as P_2O_5 in the effluent of trickling filters and surmised that considerable amounts had been precipitated by the iron in the filters. The above reported quantity of P_2O_5 in the effluent would amount to from 0.3 to 0.5 gram per capita.

On the basis of a dozen different domestic sewage samples, the average amounts of P_2O_5 left after settling was about 1.3 grams per capita and after passage through filters about 0.2 gram per capita, corresponding to removals of about 33 and 90 per cent respectively. The readily available information may be summarized as follows, expressed in percentage removal by the various processes:

	American	English	German	Russian
Settling	50–60	50–60	70	55
Filtration	75–80	75	70	80
Activated sludge	80–90	85–90	—	—

The percentages of removal given for Germany are for results obtained in the Ruhr district, where the sewage usually contained considerable quantities of iron, causing the phosphates to be precipitated, which resulted in higher removals by settling.

The removal of P_2O_5 obtained by irrigation is highest of all treatment processes and amounts to about 95 per cent.

A considerable amount of information is available regarding the P_2O_5 content of sewage sludges produced in this country (13) and abroad. The ranges for the principal sludges produced in various countries were found to be as follows, expressed as per cent P_2O_5 on a dry solids basis:

Type Sludge	United States	England	Germany	Holland
Raw primary	1.2–3.6	0.6–2.8	0.3–2.6	1.0–2.1
Humus	1.2–4.2	1.6–3.2	1.2–3.8	1.4–3.8
Activated	1.9–6.6	2.1–4.2	2.1–3.9	—
Digested	0.6–3.8	0.8–3.6	1.1–3.1	0.6–2.8

Of interest is that the percentage P_2O_5 in the sludges reported in the United States show a wider and higher range than those reported from other countries. The average analyses from a number of plants in this country were found to be as follows:

Type Sludge	No. Plants	Ave. P_2O_5 (%)
Primary sludge	11	1.61
Settled and digested	69	1.73
Humus	9	3.49
Activated	11	4.27
Mixed raw and activated, digested	6	1.98

For a number of good and sufficient reasons quantities of nitrogen in sewages, effluents and sludges have been emphasized in sewage treatment. In view of the fact that the P_2O_5 content of sewages appears to be from 20 to 50 per cent of the nitrogen content and varies in sludges from 40 to 50 per cent of the nitrogen content, it would seen that phosphorus may play a definite role in coagulation and dewatering, and may presumably affect sludge digestion. The lack of specific information is rather surprising.

Relation Between Phosphates and Strength of Sewage

It has been stated previously that the phosphate content of weak sewage was less than that of strong sewage. To determine the relation between strength of sewage and its phosphate content, samples of sewage containing industrial waste were collected hourly at a plant from 6 A.M to 5 P.M. As indices of strength the determinations of suspended solids and ammonia were selected. The samples were analyzed for NH_3, PO_4 and suspended solids in the raw sewage, and the electrical resistance was recorded. The experiments were repeated on several days.

Since the strength of domestic sewage is indicated by the ammonia content and since most of the ammonia present is derived from urine, it may be expected that there would be a fairly direct relationship between the ammonia and phosphates found in sewage. This is illustrated in Figure 1A where the NH_3-N and P_2O_5 contents of raw sewage samples are compared. The general relationship between ammonia and phosphate content is clear, but there appear to be other factors which may cause variations.

The other index of strength of sewage used was total suspended solids. The relation between phosphate content and suspended solids in sewage (Figure 1B) appears to be closer than that between phosphate and ammonia content. It is quite clear, however, that the phosphate content varies with the strength of the sewage.

Early morning sewage with relatively low ammonia and suspended solids contents contained from 11 to 12 p.p.m. P_2O_5, whereas with several times higher ammonia and suspended solids contents, the quantities of P_2O_5 did not increase in proportion. The ratio between P_2O_5 and ammonia content varied to a greater extent than the ratio between P_2O_5 and suspended solids. The relatively greater increases in ammonia than in P_2O_5 in this particular sewage are due to the presence of certain amounts of trade waste containing phosphates.

The relation between electrical resistance of the raw sewage and the P_2O_5 content is striking (Figure 2). With the increase in phosphate content a corresponding decrease in resistance is shown. The buffer action of the phosphate in sewage is well illustrated.

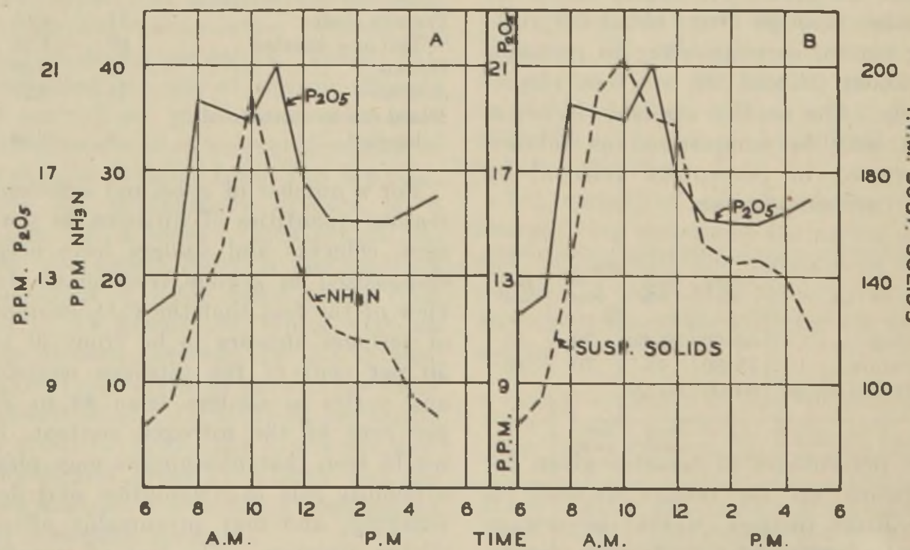

FIGURE 1.—Relation between NH_3–N and P_2O_5 (A) and between suspended solids and P_2O_5 (B) in raw sewage.

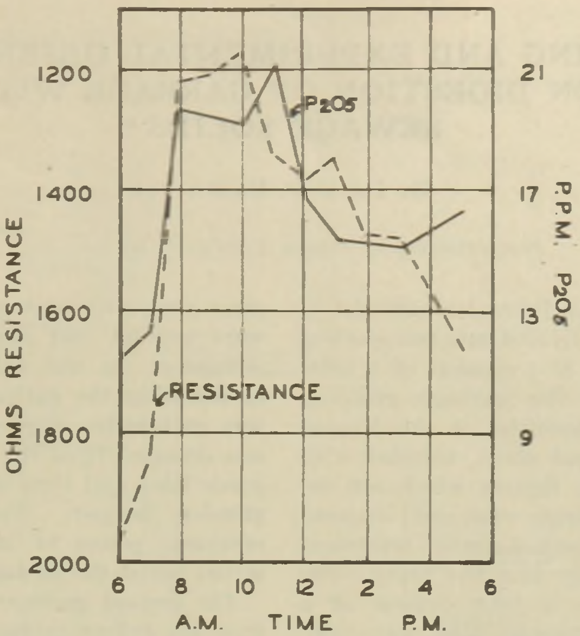

FIGURE 2.—Relation between electrical resistance and P_2O_5 in raw sewage.

Summary

The quantities of phosphorus discharged by humans is fairly constant. The amount of P_2O_5 present in domestic sewage appears to vary from 1.5 to 3.4 grams per capita per day. From 50 to 60 per cent of the phosphates present in raw sewage is removed by settling, about 75 to 80 per cent by settling and trickling filters, and about 80 to 90 per cent by the activated sludge process. Figures available for other countries do not materially differ from those in this country. There is a fairly direct relation among the ammonia, the suspended solids and the P_2O_5 contents of raw sewage. The relation between electrical resistance and P_2O_5 content of raw sludge is shown.

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OPERATING AND EXPERIMENTAL OBSERVATIONS ON DIGESTION OF GARBAGE WITH SEWAGE SOLIDS *

By David P. Backmeyer

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The data and discussion material in this paper are divided into two sections or parts. The first consists of a brief description of the garbage grinding and disposal facilities at the Marion sewage treatment plant, together with some operation figures which are intended to illustrate what dual disposal has done both to and for the treatment plant during the past five years. The second part is a brief review of a series of experiments that were conducted with small digestion units of 25 gallons each. This latter work is not yet completed, and more information will be available from it later.

Dual Disposal Experience

About five years ago the first motorized collection equipment was purchased and put into use by the City Garbage Department. As the then recently completed sewage treatment plant was equipped for grinding and disposing of garbage, city officials at that time were anxious that this equipment be given a fair trial, in an effort to find a sanitary method for final disposal of the garbage. In the month of May, 1941, 18 tons of green garbage were brought to the plant for grinding as a first test of the facilities provided in the original plant.

Handling of Garbage

The garbage disposal installation was more thoroughly tested during the next few months. In September of the same year, 162 tons of green garbage were ground and added to the raw sewage at the wet well. The method of handling the garbage at the plant was extremely simple. The garbage was dumped from the trucks onto the grade floor and then shoveled into the grinder hopper. Tin cans, trash, crockery, pieces of metal, etc., were sorted out as the garbage was shoveled.

The ground garbage was discharged from the Jeffrey garbage grinder to the raw sewage wet well beyond the sewage screens. The raw sewage pumps then discharged the garbage solids with the sewage solids to the grit channel for the removal of sewage grit and garbage mineral matter. Preaeration tanks at the head end of the primary tanks afforded a means of releasing the grease for removal by skimming at the effluent ends. The main bulk of the garbage solids was removed as sludge with the sewage solids, and pumped to the digesters for digestion.

Three definite problems soon arose from this method of handling the garbage solids. First, an excessive amount of time was required for drawing sludge from the primary tank sludge hoppers. When seven or eight tons of garbage were handled in one day, one operator would spend most of the day getting the sewage-garbage sludge mixture into the digesters. Secondly, the load on the secondary treatment, which is by activated sludge, was found to be considerable as a result of the release of colloids and solubles from the finely ground garbage. In the third place, a large amount of floating material

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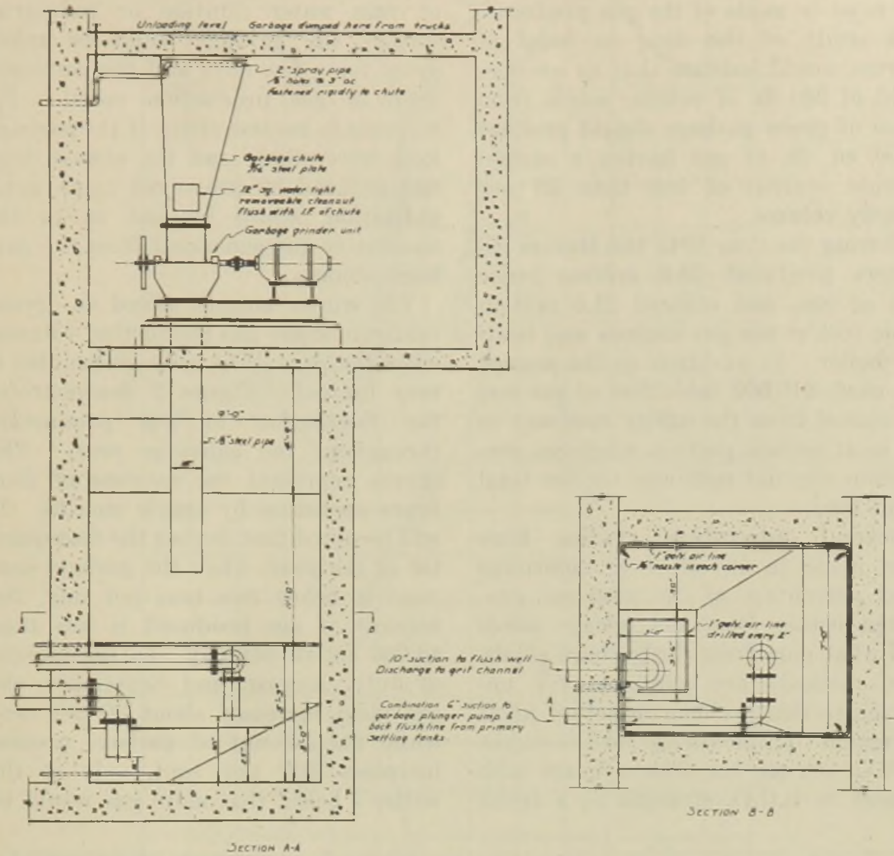

FIGURE 1.—Garbage receiving and mixing well at Marion, Ind., sewage treatment plant.

would get past the grease skimmers and make an unsightly mess when it would collect on the wiers of the final settling tanks. The answer to these problems seemed to lie in the development of a system in which the garbage could be gotten into the digesters without first mixing it with the sewage.

In May of 1943, the flooded condition of the Mississinewa River permitted by-pass of the flow to the treatment plant for a few days, and during this period a portion of the raw sewage wet well was partitioned off for use as a separate garbage well. The necessary piping was installed for removal of the garbage, and for cleaning out the residue from the bottom of the well. The general plan of the well as it is being used today is shown in Figure 1.

Several changes in the method of mixing the ground garbage have been made in the past two years. The agitation in the well must be sufficient to prevent the garbage solids from "caking" at the surface of the accumulation, this trouble being more pronounced during the corn canning season. If the ground garbage is left in the well for a period of 10 to 24 hours, lime must be added to control the pH. Two bags of hydrated lime (100 lb.) are usually sufficient to hold the pH above 6.0 when the 3,600-gal. batch is not pumped to the digesters for a period of 18 to 24 hours.

Gas Production and Utilization

If the process of disposal of garbage by digestion with sewage solids is to be an economical one, some practical use must be made of the gas produced.

A study of the data on hand at Marion would indicate that an average yield of 260 lb. of volatile solids from a ton of green garbage should produce 2,600 cu. ft. of gas having a carbon dioxide content of less than 35 per cent by volume.

During the year 1945 the Marion digesters produced 23.6 million cubic feet of gas, and utilized 21.5 million cubic feet at the gas engines and heating boiler. In addition to the sewage gas used, 640,000 cubic feet of gas was purchased from the utility company to fill in at certain periods when gas production was not sufficient for the total plant load.

Several interesting studies have been made in an effort to determine what percentage of the total gas generated comes from the sewage solids and what part from the garbage solids. Two methods are available for approach to this problem in actual plant operation. If the sewage load is stable, that is, not too far from average with respect to B.O.D. strength as a result of rain water dilution or industrial wastes, the garbage could be taken away for a few days and the resultant drop in gas production noted. By working in reverse order, if the garbage load were stable and the sewage load was reduced by prolonged rains, some indication would be had as to the amount of gas generated from the garbage alone.

The winter months afford an opportunity to study gas production volumes when the amount of garbage handled is very limited. Figure 2 demonstrates the fluctuation in gas production throughout the calendar year. The curves represent the average of four years operation by single months. It will be noted that during the first quarter of the year, when the garbage tonnage is below two tons per day, the amount of gas produced is less than 49,000 cu. ft. per day. In the months of July, August, and September, the gas yield increases about 30 per cent while the amount of garbage ground increases 400 per cent. It is the writer's belief that more gas would be

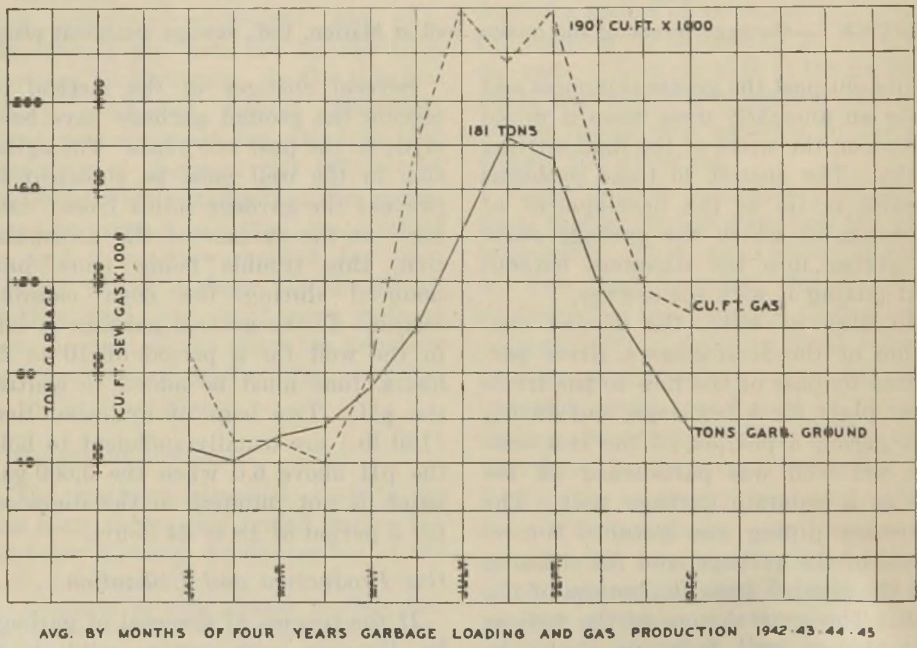

FIGURE 2.—Four-year record of gas production.

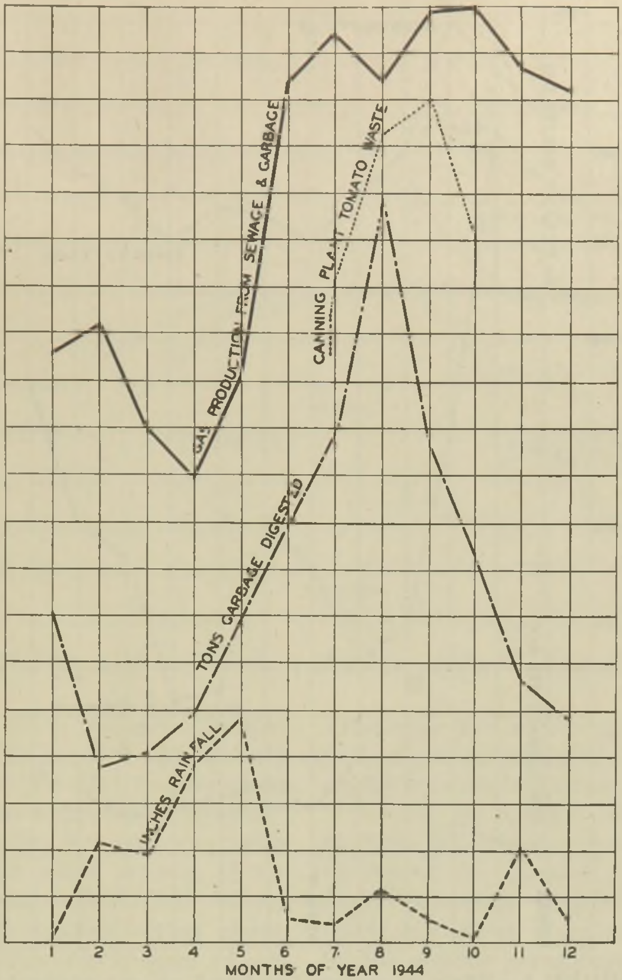

FIGURE 3.—Relation between garbage load and gas production.

collected in the summer months if more digestion capacity were provided.

Figure 3, which is reprinted from the fourth annual report of operations, shows the relationship of the various factors affecting the production of gas during the year 1944. Here the rainfall curve and the canning plant load curve are included, as both of these factors have a definite bearing on the sewage organic load.

Figure 4 is intended to show the sag in gas yield when rain water washes out the gas-producing sewage solids, and the garbage solids must produce most of the gas. The B.O.D. curve indicates the drop in organic matter in the sewage, with the resultant drop in gas volume from 49,000 to 26,000 cu. ft. per day. Had this "washout" occurred in July, the actual drop would have been about the same, but the range would have been from 75,000 to 52,000 cu. ft. per day. The greatest volume of gas produced in any one single day was recorded in September, 1945, when 97,108 cu. ft. were metered.

In August, 1946 it was possible to study an 11-day period during which time no garbage was taken at the plant. The average daily gas production in this period was 23 per cent below the

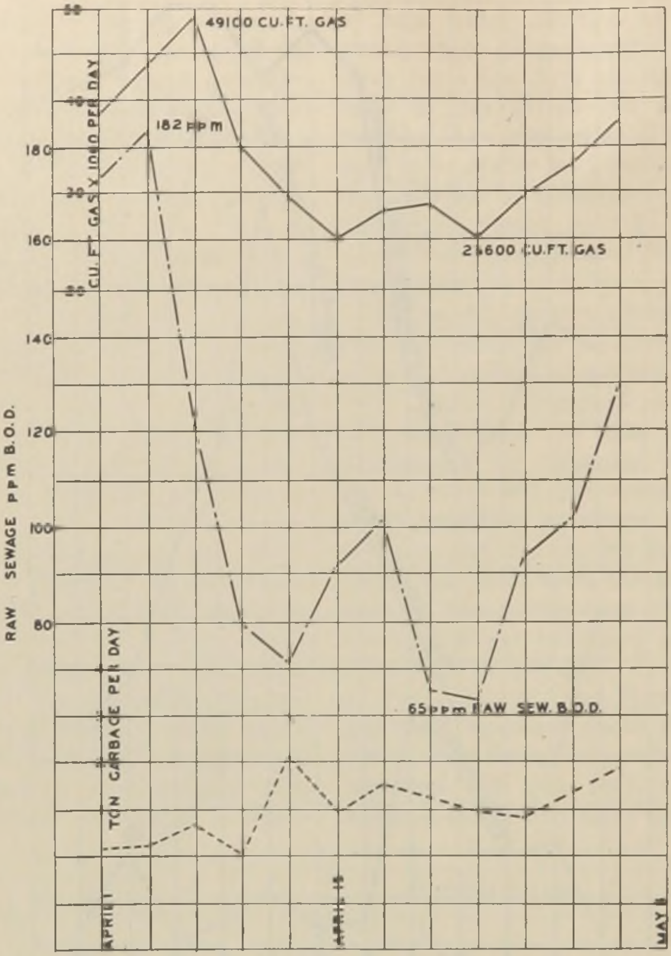

FIGURE 4.—Effect of sewage "washout" on gas production.

average for the 15 days preceding the period. The drop was from 68,000 to 52,000 cu. ft. per day.

Digestion Capacity

The matter of digestion capacity, where garbage is to be handled in a sewage treatment plant, is a question of common concern at this time. The term "cubic feet of digester capacity per capita" may be unreliable and misleading for several reasons. Assuming that digestion is carried on at optimum temperature and loading conditions, the variables of organic loading from industrial wastes and the seasonal changes in the garbage itself would necessarily limit such figures to a specific city or town.

The expression "pounds of volatile solids per cubic foot of primary digestion capacity applied per day" would seem to be a much more reliable way to state capacity ratings. Some of the peculiar characteristics of ground garbage may even make this method of comparing capacities questionable.

In referring to the digester loading at the Rahway Valley treatment plant, with sewage sludge only, Fontenelli and Rudolfs * reach the conclusion: "the optimum loading capacity for

* This Journal, 17, 4, 692 (July, 1945).

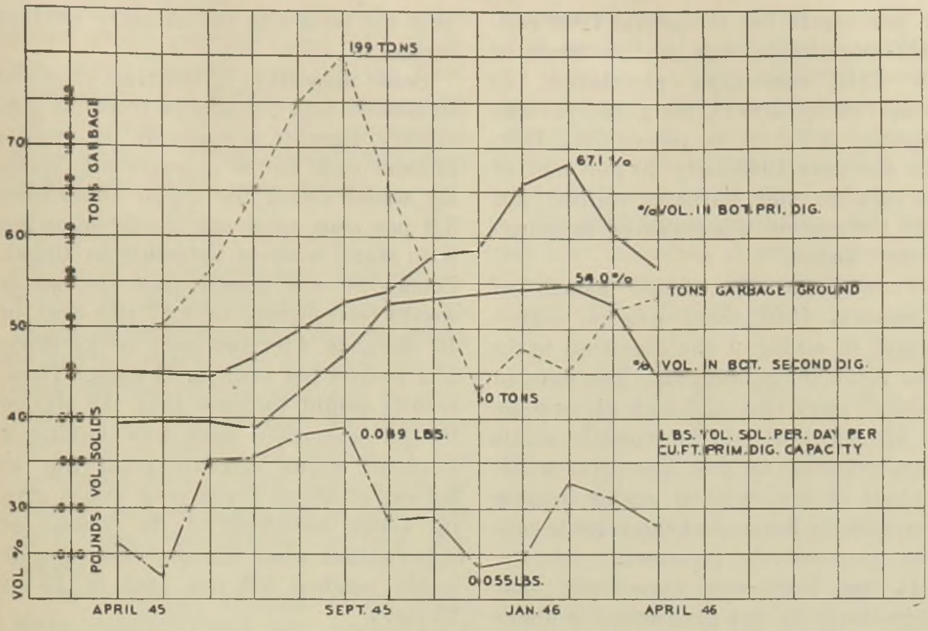

FIGURE 5.—Volatile content of bottom sludge in digesters.

each 1,000 cu. ft. of primary digestion capacity would be 100 lb. of dry volatile matter per day, producing 50 per cent clear supernatant liquor.'' At no time during the past two years has the volatile solids loading at the Marion plant reached the 0.10 lb. per cu. ft. per day loading stated above, yet the apparent overloading of the digestion system has produced a supernatant liquor in the secondary digestion tank that will contain 2.5 per cent total solids for several successive weeks at a time. This situation can be accounted for in part by the fact that some of the ground garbage particles are transferred from the primary digester to the secondary digester each day, and as a result the secondary digester is continuously active in producing gas.

It would seem logical that not only the loading of volatile matter, but also the number of cubic feet of gas produced per day per cubic foot of capacity at hand would materially affect the ability of the digester to produce satisfactory supernatant liquor. Figure 5 illustrates the rather unusual condition which developed in the primary digester during the latter part of 1945.

It will be noted that undigested garbage solids had accumulated in the bottom of the digester, and that very little immediate digestion of these solids was taking place, as is evidenced by the volatile percentage curve which climbed to a peak of 67.1 per cent in March, 1946. The temperature of the sludge at the bottom was surprisingly low at 56° F., while the active sludge above it was 90° F.

The temperature problem was easily solved by circulating the cold, thick sludge from the bottom to a higher elevation, where it could mix with the warmer and more active solids. This circulation resulted in an immediate increase in the amount of gas being produced. The primary digester is now circulated for two hours daily as a routine operation, and the temperature of the sludge at the bottom is above 75° F.

The Marion treatment plant has a designed digestion capacity of 6.25 cu.

ft. per capita for the actual 1940 resident population, but on the basis of the 1945 equivalent population, as measured by B.O.D. tests, the present capacity is 4.2 cu. ft. per capita. During the year 1945 only 20 per cent of the sludge and garbage volume put into the system was removed as supernatant liquor.

Throughout the entire month of February, 1946 there was no supernatant in either of the digestion tanks that could be withdrawn. The data in Table 1 show that although an average of 72 per cent of the volatile solids were removed as gas, the total solids content of the finished sludge became increasingly lower, and the volatile content progressively increased.

It has been our experience that when the daily gas production is above 0.36 cu. ft. per cubic foot of total digestion capacity, there will be no supernatant liquor in the system that contains less than 5,000 p.p.m. total solids. At the same time, it does not follow that lower gas yields will always produce supernatant liquor suitable for return to the primary settling tanks.

Some indication of the time required to concentrate the sludge from the secondary digester is given by the results of tests made on the supernatant liquor. By withdrawing the liquor containing 3.0 per cent total solids and allowing it to stand without agitation in 40-gal. drums, it was found that the solids would concentrate to 4.47 per cent in 10 days, to 4.98 per cent in 13 days, and to 5.04 per cent in 24 days. These results would indicate that the sludge in the secondary tank now having a uniform solids content from top to bottom of about 3 per cent would give up about one-third of its volume as supernatant when the concentration of solids reached 5.0 per cent in 13 to 15 days.

The present volume loadings will average about 26,000 gal. of sludge and garbage per day the year through. To get an additional 15 days digestion time, the present total digestion capacity of 167,000 cu. ft. should be increased 31 per cent to give a total

TABLE 1.—Data on Garbage-Sludge Digestion at Marion, Ind.

Month	Volatile Solids Loading		Bottom Sludge in No. 1 Digester		Volatile Solids Removed as Gas (lb.)	Volatile Solids Reduction (%)	Raw Sludge Total Solids (%)	Ground Garbage Total Solids (%)	Digested Sludge	
	Pounds	Lb. per Cu. Ft. per Day[1]	Solids (%)	Volatile (%)					Total Solids (%)	Vol. Solids (%)
1945										
April	154,500	0.062	4.55	45.0	109,000	70.5	5.29	6.00	4.19	38.9
May	143,200	0.055	4.36	44.6	116,300	81.4	4.99	5.13	4.55	39.7
June	202,000	0.081	4.00	44.3	136,500	67.5	5.93	4.23	4.22	39.8
July	210,200	0.081	3.94	45.2	150,800	71.7	5.40	4.24	4.07	39.2
August	224,200	0.086	3.37	48.8	145,500	65.0	4.55	4.11	3.74	43.0
September	223,900	0.089	2.98	52.8	160,500	71.7	4.39	5.23	3.18	46.6
October	172,800	0.067	2.84	54.6	118,100	68.4	4.09	4.52	3.10	52.1
November	171,300	0.068	3.34	57.5	125,300	73.2	4.66	5.00	3.47	52.9
December	140,200	0.054	3.40	58.7	112,000	80.0	3.86	4.55	3.41	53.2
1946										
January	144,400	0.076	4.90	65.6	110,900	79.0	4.71	5.84	3.17	53.9
February	178,600	0.076	5.05	67.1	110,900	62.0	4.72	6.88	3.71	54.0
March[2]	189,900	0.073	5.16	60.8	132,700	69.8	5.37	7.85	3.55	52.0
April	169,200	0.067	3.44	56.8	130,000	76.7	4.16	9.12	3.54	43.9

[1] Based on primary digester capacity.
[2] Recirculation of bottom sludge started on March 20.

capacity of 219,000 cu. ft. This latter figure would give the plant 8.21 cu. ft. per capita on the basis of the 1940 population, and 5.22 cu. ft. per capita on the basis of the 1945 equivalent population. These populations were 26,700 and 42,000 respectively.

Separation of Grit and Debris

One of the troublesome features involved in adding ground garbage directly to the digesters in preference to mixing it with the raw sewage has been the removal of grit and mineral matter from the garbage. The separate well system shown in Figure 1 has been used for the past three years at Marion, and no stoppages in pipe lines have been encountered during this period.

The removal of egg shells, bone chips, crushed peach pits, seeds, bottle caps, and various other non-digestible materials by flushing them out the bottom of a properly constructed well would appear to work out in a satisfactory manner. This statement is substantiated by the record of grit removal, which shows that during the eight months of June, July, August, and September of 1944 and 1945, the average volume of grit removed per month was 65 per cent above the average removal per month for the full two years. In this same 8-month period the amount of garbage handled per month was 50 per cent above the average tonnage per month for the full two years. Some traces of egg shells, coffee grounds, chicken feathers and other fibrous materials are found in the digested sludge, but not in quantities sufficient to cause caking at the top of the digester or plugging of the sludge draw-off lines.

Summary of Operation Experience

If the garbage disposal installation at Marion has any single quality worthy of special mention, that quality would be simplicity. No special skill or training is required of the men in charge of any part of the installation. The mechanical equipment is confined to two units, the Jeffrey garbage grinder and the Chicago single-piston plunger pump. Both units have performed the functions for which they were installed in an excellent manner.

The following conclusions are based on the five years of experience in digesting sewage sludge-garbage mixtures at the Marion plant:

1. In a properly constructed garbage well, sufficient grit and foreign non-digestible matter may be removed from ground garbage so that the remainder of the garbage solids can be digested with sewage solids without difficulty in a properly controlled digestion system.

2. The gas produced from the digestion of garbage solids with sewage solids is of a quality that will permit its use in gas engines and gas-fired heating boilers.

3. The loadings (garbage solids plus sewage solids) of 0.1 lb. of volatile solids per cubic foot of primary digestion capacity per day are too great to allow withdrawal of clear supernatant liquor from the digestion system, with two-stage digestion at temperatures at 90° F.

Digestion Experiments

A previous report of pilot plant experiments on digestion of garbage solids was made in the June, 1946 issue of *Sewage Gas*, published by the Indiana State Board of Health. Some of the previously published data will be included in the summary that follows.

Test Procedure

The equipment used in the experimental work consists of three digestion units as shown in Figure 6. Each unit was made up of a 25-gal. used paint drum, a sheet metal gas collection dome of about 16 in. diameter and a side wall skirt of 19 in., and a heating unit

FIGURE 6.—Pilot digesters used for garbage digestion experiments.

at the bottom for maintaining temperature control.

The general procedure was to digest raw sewage sludge or ground garbage solids in two of the three drums, and reserve the third unit as a control for the digestion medium. Throughout the course of the tests many variations of this procedure were used.

The top of each collection dome was fitted with a 3/8 in. outlet so that the gas collected could be released and analyzed conveniently. The volume of gas collected was measured by the "inches rise" of the collection domes; the weight of the domes provided a working pressure of 1.75 in. water column on the gas collected.

The results of eight of the tests made are summarized in Table 2. Three graphs are shown which demonstrate the gas production rates as measured by the rise of the gas collection dome each day. In Figure 7 it will be noted that the test was continued for a period of 34 days, but that about 40 per cent of the total gas production took place in the first five days. A supernatant liquor of good quality was obtained at the end of the 34-day period as is shown by the B.O.D. content of 157 p.p.m.

TABLE 2.—Results of Garbage Digestion Experiments at Marion, Ind.

Test Number	1	2	3	4	5	6	7	8
Date started	3/10/45	3/10/45	8/30/44	8/30/44	1/16/46	4/23/46	4/23/46	4/23/46
Material digested	Garbage	Garbage	Garbage	Sludge	Garbage	Garbage	Garbage	Garbage
Dry solids (lb.)	1.02	1.02	2.74	2.66	5.17	0.55	0.55	0.55
Volatile solids (lb.)	0.92	0.92	2.45	1.25	4.74	0.48	0.48	0.48
Seed material	Digester supern.	Digester supern.	Water supern.	Water supern.	Digester supern.	From Test 5	90-day supern.	90-day supern.
Temperature (°F.)	79	79	90	89	116	84	80	80
Total gas (cu. ft.)	11.48	13.05	18.93	9.02	38.6	8.8	7.53	7.27
Gas per lb. vol. (cu. ft.)	12.43	14.1	7.73	7.2	8.15	18.3	15.7	15.1
Per cent of vol. removed as gas[1]	80.7	99.1	50.3	46.7	52.8	100+	100+	98.6
Gas pressure (in. water)	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Per cent of total gas yield in 5 days	73.0	76.3	50.0	78.6	—	38.1	25.2	24.5

[1] 100 cu. ft. gas considered to represent 6.5 lb. volatile solids.

Figure 8 shows the results of two tests made over a period of 16 days. In the test represented by the broken line curve, 76.3 per cent of the total gas generated was produced in the first five days of the period. The solid line curve demonstrates the relation of the CO_2 content of the gas to the pH as the digestion rate changes over the 16-day period.

In Figure 9 the broken line curve represents the digestion of 0.92 lb. of volatile garbage solids in a digestion medium of 135 lb. of digester supernatant having a total solids content of 3.51 per cent. In this test 80 per cent of the garbage volatile solids were accounted for as gas, with the yield being 12.43 cu. ft. of gas per lb. of the garbage volatile solids. The

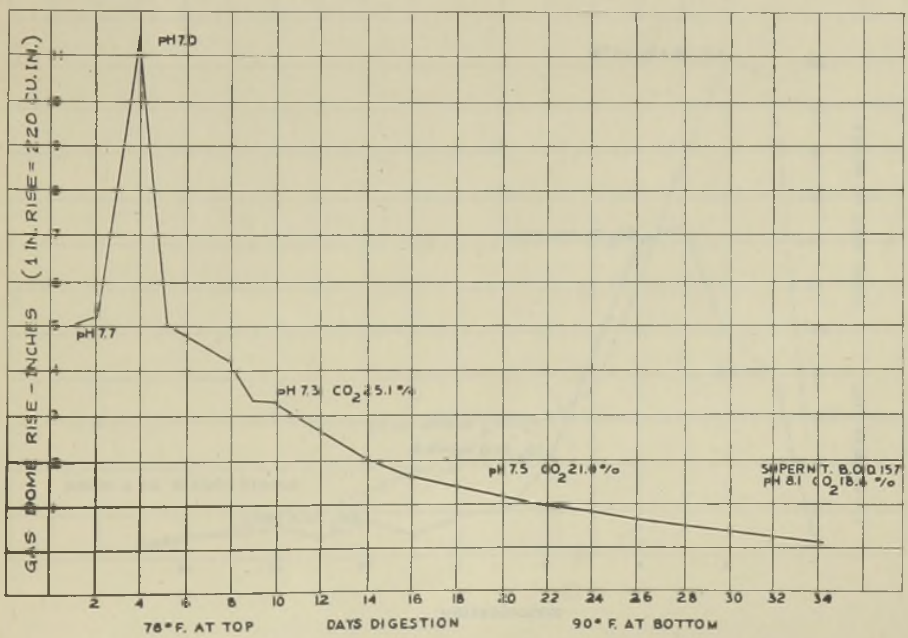

FIGURE 7.—Garbage digestion experiment of 34 days duration.

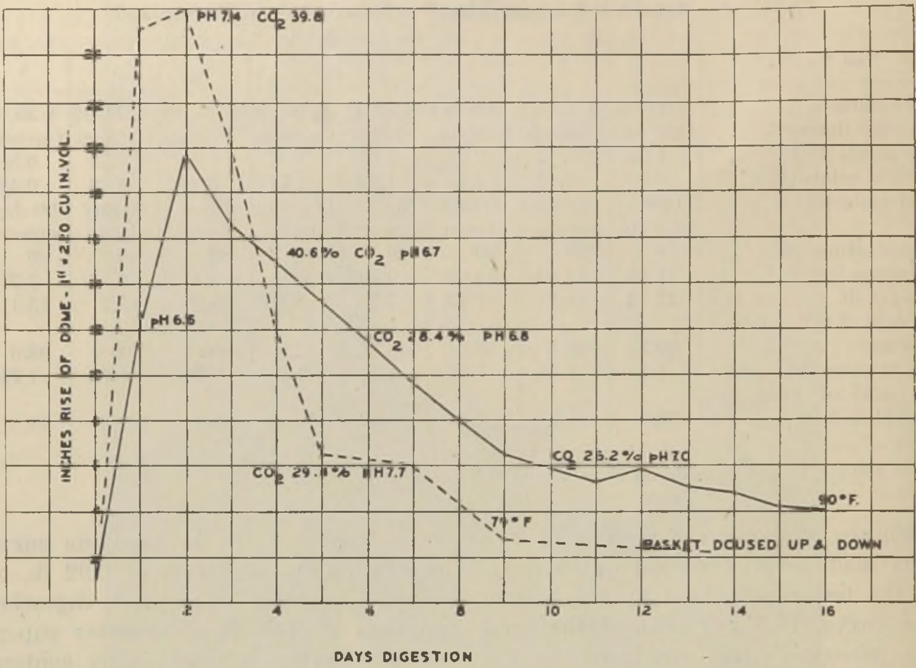

FIGURE 8.—Comparison of results of two experiments in garbage digestion.

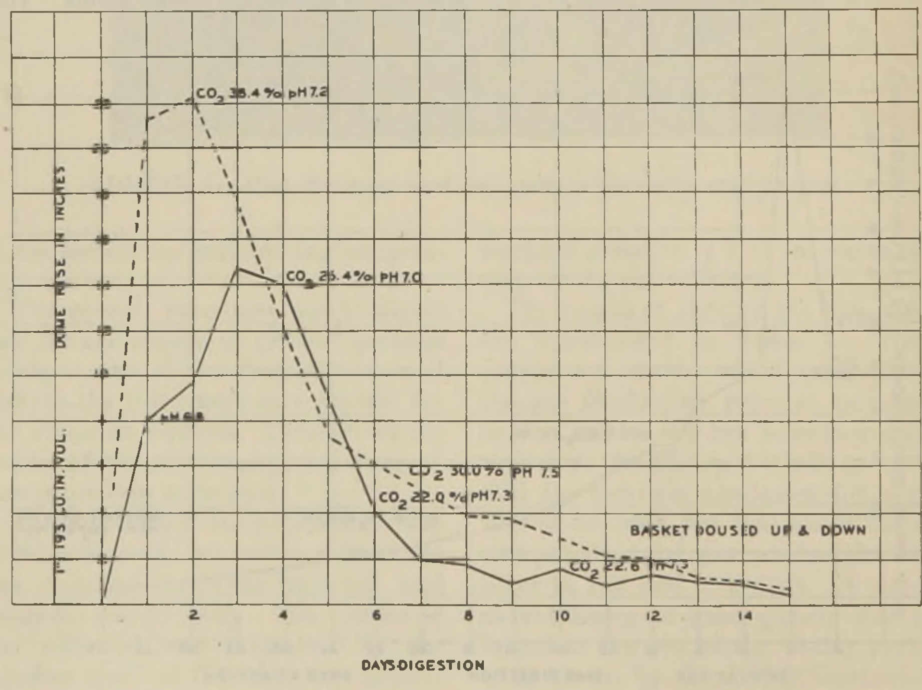

FIGURE 9.—Comparison of results from garbage and sludge digestion experiments.

solid line curve in the graph shows the gas production trend when raw primary sewage sludge is digested. In this test 78.6 per cent of the gas was produced in the first five days, and the yield was 7.2 cu. ft. per lb. of the sewage sludge volatile solids.

The loadings in all of the tests were of the "batch" type. Cumulative loading tests are to be made in the future on both the garbage and the raw sewage sludge.

The average of seven tests made with garbage showed that 13.1 cu. ft. of gas were produced from a pound of garbage volatile solids. Without exception, the CO_2 content of the gas was higher at the beginning of the run when the gas production rate was greater. In digesting samples of spent brewers grain and of cheese whey it was found that the CO_2 content of the gas would rise to 63 per cent at the start of the test, and then drop sharply to a low of 20 per cent after a period of nine or ten days. This would tend to indicate that different types of garbage (due to seasonal variation of diet) might produce a large volume of gas having little fuel value in some cases.

The results of two tests made on raw sewage sludge gave an average of 8.26 cu. ft. of gas per lb. of volatile solids digested. In actual plant operation during the winter months when garbage loadings are low, the yield from garbage and sewage sludge together was 8.12 cu. ft. per lb. of volatile solids. As the actual amount of garbage handled during this part of the year is less than two tons per day, it could be assumed that this value would largely represent gas generated from sewage sludge only.

The tests made to date would tend to indicate that a given weight of volatile material in garbage would produce a greater volume of gas than a similar weight of volatile solids found in sewage sludge. Further investigation is necessary, however, before definite conclusions can be drawn.

Industrial Wastes

INDUSTRIAL ALCOHOL PRODUCTION FROM SULFITE WASTE LIQUOR BY THE ONTARIO PAPER CO., LTD.*

By H. G. Joseph

Superintendent, Alcohol Plant, Ontario Paper Co., Ltd., Thorold, Ont., Can.

During 1941 and 1942 it became evident that the productive capacity of the alcohol industry was considerably short of the greatly increased demand incurred chiefly by the pyramiding of wartime needs upon a peace time structure. This situation brought about far-reaching changes in the usual methods of production and distribution of ethyl alcohol.

Under normal conditions, Customs and Excise duties and tariffs prohibit the crossing of alcohol into the United States unless such alcohol is to be utilized in the manufacture or blending of beverages where the selling price is sufficiently high to absorb such charges. An agreement was reached by which industrial alcohol could be imported free of any charge into the United States for use in essential war materials, such as synthetic rubber and explosives, etc. However, even after the expansion of productive capacity in Canadian and American distilleries and the availability of Canadian alcohol in the United States, the demand for alcohol far exceeded the supply.

To assist in satisfying this demand, The Ontario Paper Company, Limited, at the request of the Canadian Department of Munitions and Supply, and at its own expense, commenced the construction of an alcohol plant to manufacture alcohol from waste sulfite liquor.

Of great value in carrying out this project to a successful conclusion was the fact that the services of Dr. M. M. Rosten, a consulting chemical engineer, were available. Dr. Rosten, before the war, owned and operated the Kutno Chemical Works in Poland which produced absolute alcohol and its derivatives. The Kutno plant began production of power alcohol in 1927 and was the first of its kind in Eastern Europe. Dr. Rosten contributed largely to the design, installation, and initial operation of the plant at Thorold. A little over eight months elapsed from the time that construction was commenced until the first carload of alcohol was shipped. During this period there was a continuous struggle with priority difficulties and shortage of appropriate materials, but the plant finally came into production in May, 1943.

Various Methods of Producing Alcohol

The methods and economics involved in the production of ethyl alcohol are in general determined by two basic factors: the raw materials available for processing and the use to which the alcohol is to be put. In certain cases the use to be made of the alcohol will determine the kind of material selected. Social and political forces exert an influence on alcohol manufacture, par-

* Presented at 19th Annual Meeting, Federation of Sewage Works Assns., Toronto, Can., October 7–9, 1946.

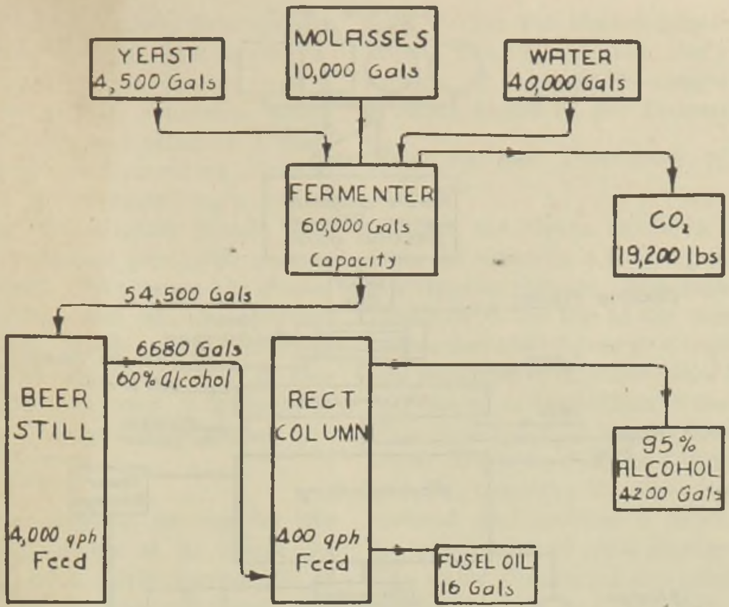

FIGURE 1.—Flow sheet for conventional production of alcohol from molasses.

ticularly when beverage spirits are concerned. Alcohol for beverage purposes, however, which is usually made from grain, is outside of the field in which we are concerned.

In Canada before the war nearly all of the industrial alcohol produced was derived from blackstrap molasses imported from the West Indies and Cuba. The molasses, containing 50 to 55 per cent sugar, is mixed with three to four times its volume of water; yeast is added and a fermentation takes place converting the sugars present into alcohol and carbon dioxide. After a period of 24 to 30 hours the fermentation is completed and the molasses-water mixture, now containing 7 or 8 per cent alcohol, is passed through a series of distillation columns, which recover the alcohol at a high strength and degree of purity. Figure 1 shows the flow sheet for a conventional molasses distillery and affords an interesting comparison with that of our waste sulphite liquor alcohol plant, which is set forth in Figure 2.

The production of alcohol by fermentation involves the breaking down of simple sugars by yeast to form alcohol and carbon dioxide. When the sugars are readily available, as in the case of molasses and waste sulfite liquor, alcohol production is simplified since the fermentation can be inaugurated with a minimum of operations on the material to be fermented, *i.e.*, mixing, cooling or neutralizing. To process starchy materials, such as corn, wheat, and barley, it is necessary to grind the grain, cook it in order to gelatinize the starch, then convert the starch into sugars by means of mashing (diastatic conversion) or hydrolysis (acid conversion). Only after such steps are the starches converted into fermentable sugars which are readily acted upon by yeast. This mashing of materials involves considerable expenditure of steam, power, and water, and it is obvious that alcohol made in this manner is expensive and must be utilized in a manner that will realize a return commensurate with the expense incurred.

The Sulfite Alcohol Plant

As far back as 1878, nearly seventy years ago, A. Mitscherlisch, who was

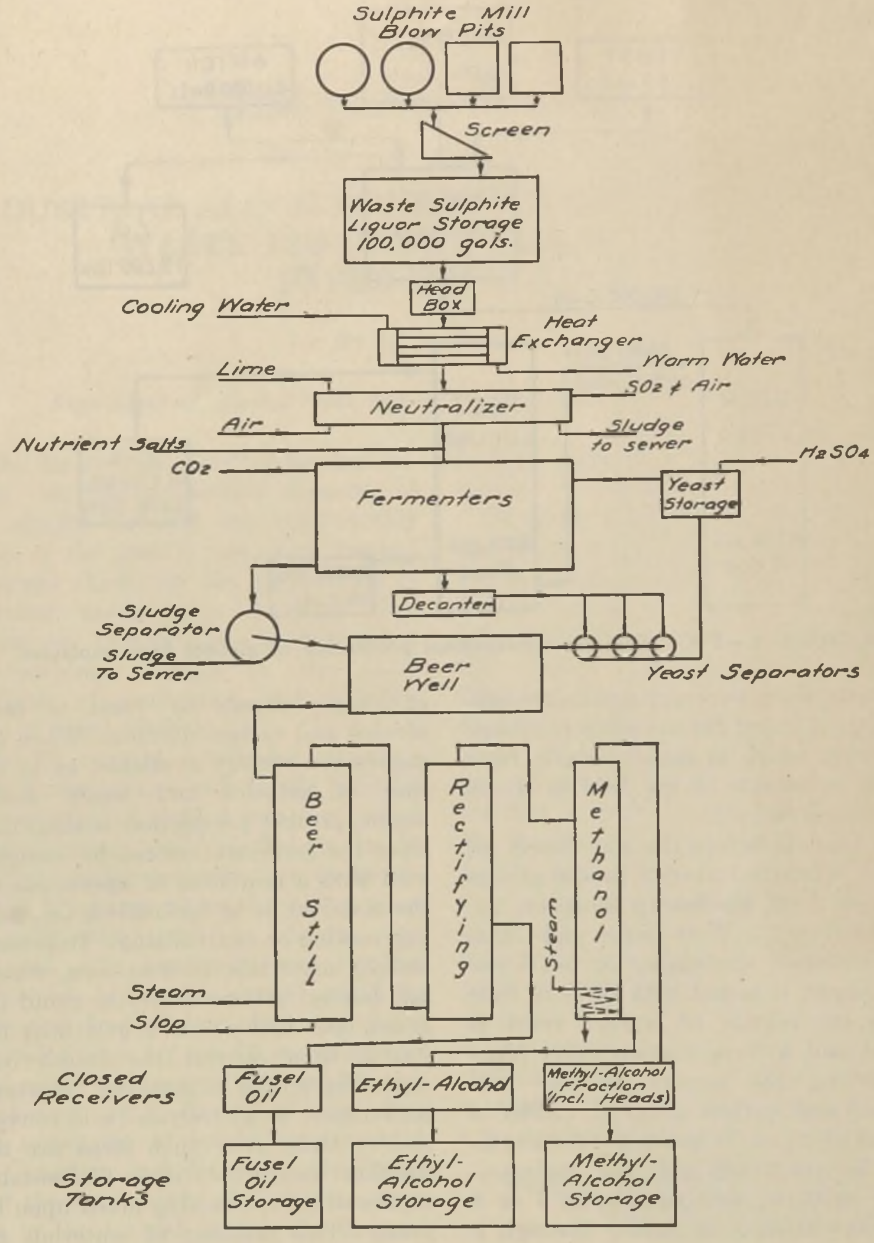

FIGURE 2.—Flow sheet for alcohol plant of the Ontario Paper Co., Ltd., at Thorold, Ont. Stripping column between blow pits and screen not indicated.

one of the pioneers of the sulfite cooking process, recognized the possibility of producing alcohol from the waste liquors deriving from cooking of wood, carried out experiments and obtained a patent on his results (1). Nearly thirty years were to elapse before the first plant was built in Sweden.

Various considerations contributed to this long delay. The sulfite cooking process, being of an acid nature, was extremely hard on equipment, which tended to delay the rapid development of the process, while the low concentration of sugars in the liquors was a handicap in certain countries where spirit production was taxed on a basis of the size of the fermenting division of the plant. In the early stages alcohol yields were low, slightly better than 6 gallons of alcohol per 1,000 gallons of waste liquor; the process has gradually improved, and at the Thorold plant, as the result of a technique which will be described later in this paper, yields are over 9 gallons of alcohol per 1,000 gallons of liquor.

Source of Liquor

The sulfite cooking process for the making of pulp has as its object the preparation of a fairly pure form of cellulose. To do this, softwood trees such as pine, spruce and hemlock are cut into logs and then into chips. The chips are fed into large digesters and covered with a solution of calcium bisulfite and sulfur dioxide in water. The digester is closed and live steam introduced for several hours. The effect of the cooking is to bring into solution the binding or cementing ingredients of the wood known as lignins and hemi-celluloses, leaving the cellulose or fibres practically unaffected.

The contents of the digester are released into the blowpit, the waste liquor being drained off through perforated plates in the bottom of the pit, and collected in a storage tank. This waste liquor, which is the primary material for the alcohol plant, contains about 12 per cent solids, 2 per cent sugars and dissolved sulfur dioxide in a free condition and combined with lignin. The sugars present consist of hexoses and pentoses, only the former being fermentable, and comprising about 70 per cent of the total sugars.

The amount of waste liquor available each 24 hours is about 250,000 gallons. However, the Best Yeast Limited, who manufacture bakers' or compressed yeast, utilize about 10 per cent so that the alcohol plant receives about 225,000 gallons daily. The amount of fermentable sugars present is about 34,000 lb. per 24 hours.

Handling and Processing of Sulfite Liquor

After the liquor has been collected from the blowpits it is first put through a stripping column. The liquor is introduced at the top of the column and passes downward over perforated stainless steel plates in counterflow to steam introduced at the bottom of the column. This treatment of the liquor removes about 25 per cent of the sulfur dioxide present, lessening its corrosive characteristics and making it more suitable for production of good quality alcohol. The gases eliminated are returned for further use in the sulfite mill.

The liquor from the base of the stripping column is now pumped over to the alcohol plant where it is screened and collected in a 100,000-gal. storage tank. Here it remains at a temperature of nearly 200° F. until required for use.

The next step in the process is to pass the sulfite liquor through a water-cooled heat exchanger to reduce its temperature to 90° F., which is the temperature of fermentation. The liquor is then neutralized with milk of lime to a pH of 5.5 to 6.0 and pumped to the fermenters where yeast is added and the conversion of the sugars into alcohol commences.

Fermentation and Yeast Recovery

The type of fermentation employed at the Thorold plant is of particular interest since it utilizes the "re-use of yeast" process developed by Les Usines de Melle (2), under whose patents the Ontario Paper Company, Limited, is licensed. This process has been widely used abroad but was initiated in North America when the Thorold plant adopted it. It has been one of the most significant factors in the successful operation of this plant.

The fermentation of sugars to alcohol and carbon dioxide is brought about by yeast activity, and in order to do this within practical time limits it is necessary to have a definite relationship between the amount of yeast present and the amount of sugar present. Moreover, the dilution of the sugar solution will tend to lengthen the period of fermentation. It follows that a high yeast to sugar ratio is important for a speedy and efficient fermentation.

In the usual methods of producing alcohol 5 per cent or more of the sugars present may be used up in the growth of the yeast necessary to bring about the fermentation. In grain and molasses distilleries several stages of yeast reproduction may be involved, each utilizing sugar which could have been converted into alcohol.

The Melle "re-use of yeast" process utilizes the principle that by means of centrifugal separators the yeast can be recovered from the fermented liquors and used again for the succeeding fermentations, with nearly 100 per cent recovery and its fermenting powers unimpaired. The provision of fresh yeast is necessary only on rare occasions, such as the starting up of a new plant, or resuming operations after a prolonged shut-down (3).

The fermentation takes place in the following manner. Approximately 42,000 gallons of neutralized waste liquor are pumped into a pair of fermenters which are interconnected in such a way that the liquor can be circulated continually from one to the other. A charge of yeast and some nutrient salts are then added and the circulation is started. After a period of 12 to 14 hours the fermentation is complete, the tanks are allowed to settle for an hour or two, after which the contents are passed through a battery of yeast separators. Here the yeast is removed from the fermented liquor (beer) and collected in a tank for further use. The yeast separator receives fermented liquor with yeast, concentrating and discharging the yeast in about a 15 per cent solution from one outlet; from the other outlet the beer is discharged to a pair of large tanks, or beer wells, supplying feed to the stills.

Methyl Alcohol

Along with the ethyl alcohol formed by fermentation of the sugars in the liquor there is another form of alcohol present, namely, methyl alcohol. This methyl alcohol amounts to about 3 per cent of the total alcohol produced. It is formed in the pulping process as a result of the cooking of the wood. It comes over as a very small percentage of the sulfite liquor, passes through the fermentation cycle unchanged, and is separated in the final stage of distillation, since its boiling point is several degrees lower than that of ethyl alcohol.

The methyl alcohol as drawn off is not 100 per cent pure but contains a percentage of other low-boiling impurities, such as aldehydes and ketones, formed during the fermentation and earlier stages of distillation. This material has found extensive use in industry as a solvent.

Distillation

There are essentially three stages in the distillation of the alcohol present in the sulfite liquor after fermentation. These are:

(1) Removal of the dilute alcohol from the fermented liquor.

(2) Concentration of such dilute alcohol.

(3) Fractionation of impurities out of the concentrated alcohol, together with recovery of the rectified alcohol.

In the first stage the beer is fed separately into the tops of two columns, passes downward from plate to plate, and gives up its alcohol to the vapor formed by the introduction of steam to the base of these columns. The vapor contains about 10 per cent alcohol by volume and is partly condensed, then introduced into the bottom of the third column, known as the rectifying column.

In this column the alcoholic strength increases as the vapor ascends to the top and is enriched by the downward flow of liquid from the condenser. At the top of this column the alcohol attains a strength of 96 per cent by volume, and is led into the final column. The product entering the final column contains 96 per cent of alcohol and 4 per cent water, this representing a mixture which cannot be further increased in alcoholic strength without the employment of a special system of dehydration. However, the alcoholic portion of this mixture contains 3 per cent of methyl alcohol and aldehydes. As these are low-boiling constituents they concentrate at the top of the column and are drawn off continuously. The pure alcohol, stripped of all its methyl alcohol and most of its other impurities, is withdrawn from the base, passed through a cooler, and collected in the finished alcohol receiver.

Fusel Oil

During fermentation yeast activity produces types of higher alcohols in small quantities. These compounds, together with certain wood oils which steam distill, are removed from the rectifying column. While they only amount to a very small percentage (0.2 per cent) of the total distillate, their removal is very important, since their presence in quantities exceeding 60 to 70 p.p.m. substantially lowers the quality of the final ethyl alcohol.

Denaturing and Shipping

The daily production of alcohol is weighed and pumped to large storage tanks. Alcohol is taken from these tanks and mixed with denaturants according to various formulae. In this manner characteristics of a nauseating nature, in respect to taste or smell, are imparted to the pure alcohol making it unfit for potable purposes and yet suitable to the industrial purpose for which it is required.

Among the denaturants employed are wood alcohol, pyridine bases, castor oil, pine oil, benzene, camphor quassin, etc. As is the case in all distilleries, departmental officials supervise all operations, and all tanks, lines, and valves involved in the handling of alcohol are locked or sealed. Any shortage of alcohol over and above a legal allowance is heavily penalized, and once each year the plant is shut down completely so that a check can be made on production, shipments and balances on hand.

Laboratory Control of Process

To obtain the maximum efficiency in operations it has been necessary to establish and maintain analytical procedures at certain stages of the process. Sulfur dioxide, sugars, and alcohol are the main objects of such testing procedures. An excellent article on analysis of sulfite waste liquor appeared some ten years ago, written by A. M. Partansky and H. K. Benson (4).

Actual control problems, however, have resolved themselves into the determination of how much sugar is handled each day, quantity of alcohol made from such sugars, quantity of alcohol recovered by the stills, and amount of alcohol that remains in the sulfite liquor after passing through the stills and being discharged as waste.

Throughout the process one is dealing with low concentrations; in the fermentation, sugar concentration is about 1.5 to 1.6 per cent, alcohol concentration 1 per cent, while in the slop discharge from the beer stills an alcoholic content of 0.05 per cent would give cause for some anxiety over current operating conditions.

Sugar determinations are carried out by biological means using a method of fermentation with yeast and measuring the carbon dioxide evolved. This is a rapid, and generally satisfactory test, meeting the fundamental requirements of all control procedure that data must be obtained within a short period of time. It is sometimes complicated by the fact that the linkage or occurrence of sugars in the waste liquor is such that the sugar compounds break down during the plant fermentation and are converted into alcohol (and carbon dioxide), while in the control analysis, which is carried out in about one-twentieth of the time, a portion of the sugars do not have time to dissociate. Consequently, the situation may sometimes be encountered of operating at over 100 per cent fermentation efficiency.

Analysis of the alcoholic content of the waste liquor at various stages of the process also presented some difficulties. The conventional method of estimating the alcoholic content of liquids is to obtain a distillate containing the alcohol originally present. The alcoholic concentration of this distillate is ascertained by taking specific gravity or refractive index, and is known by reference to standard tables.

In determining the alcoholic content in waste liquor a relatively large amount must be taken for distillation. The distillate then contains impurities boiling within the same range as ethyl alcohol but having a refractive index and specific gravity differing considerably from alcohol.

After much investigation a method was found of dealing with the impurities so that they were removed from the boiling range of alcohol, which enabled the alcoholic content to be determined with a considerable degree of accuracy.

Progress Made in Three Years Operation

Table I illustrates in condensed form the raw materials used and the alcohol production for the months of October, 1943 and June, 1946.

When high fermentation and distillation efficiency is maintained it follows that higher production can only be secured if more sugars are supplied to the plant. During the last two years the sulfite mill has increased its daily capacity, the liquor recovery operation has been improved, and alcohol production has increased by more than 20 per cent. For about a year immediately preceding the end of the war, waste liquor was collected from the Alliance Mills at Merritton, some three miles distant, transported in rubber-lined tank trucks, and processed to produce approximately 500 Imperial gallons of additional alcohol per day. This operation was discontinued in September, 1945.

Improvements have been effected, such as the elimination of the use of sulfuric acid, decreasing the amount of lime and yeast nutrient required, and shortening the time of fermentation.

TABLE I.—Daily Average Data on Alcohol Production from Sulfite Waste Liquor

	October, 1943	June, 1946
WSL received from mills (Imp. gal.)	210,600	227,953
WSL to storage, per digester (Imp. gal.)	22,590	23,595
Specific gravity, WSL to storage	1.046	1.049
Pulp per digester (tons)	13.88	16.50
Liquor recovery per ton pulp (Imp. gal.)	1,302	1,140
Fermentable sugars (gm. per 100 ml.)	1.39	1.65
Fermentable sugars (lb.)	28,111	32,852
Nutrient salts per 100 gal. alcohol (lb.)	6.1	2.9
Lime used per 100 gal. alcohol (lb.)	431.2	266.0
Average fermentation time (hr.)	20.24	15.75
H_2SO_4 used per 100 gal. alcohol (lb.)	14.1	Nil
Ethyl alcohol from closed receiver (Imp. gal.)	1,450.9	1,805.0
Strength of ethyl alcohol (overproof)	68.8	68.7

When the plant was built, during the first six months of 1943, it was impossible to obtain corrosion-proof material. Waste sulfite liquor in any form will attack most metal, especially iron and copper, the average life for such material being about nine months. Corrosion tests were carried out at various stages in the process with a dozen different types of material, including copper, iron, steel, and acid-resistant steels. It was found that chrome nickel steel with a small molybdenum content was completely resistant to corrosion, and at this date every piece of equipment exposed to severe corrosion has been replaced in stainless steel.

Stream Pollution Aspects

In its passage through the process of alcohol manufacture the waste liquor from the sulfite mill loses a high percentage of its undesirable characteristics. This is brought about through the neutralization of sulfur dioxide and fermentation of sugars. Samples of the alcohol plant effluent examined by representatives of the Sulphite Pulp Manufacturers' Committee on Waste Disposal (Wisconsin) showed a 43 per cent reduction in B.O.D. for the liquor going through the alcohol plant. This is in line with laboratory fermentations in which B.O.D. reductions of 40 to 50 per cent were obtained (5).

Ontario Paper Company Alcohol

The ethyl alcohol which the company has now been producing for over three years has attained a broad distribution. During the war period it was shipped in its pure form to the United States for the manufacture of synthetic rubber. As such it had to conform to U. S. Army Specifications No. 1, and the alcohol complies with, and in some cases substantially exceeds, these specifications. One of the most exacting requirements to be met in the manufacture of synthetic rubber is that ingredients must be free from sulfur, this being extremely harmful to the catalyst. The sulfur content of Thorold alcohol, as independently analyzed by a well known laboratory, indicated between 1.4 and 2.1 p.p.m., which is close to the limit of determination, and no objections have ever been registered on its sulfur content.

Another question frequently asked is "If Thorold alcohol is made from wood is it not wood alcohol?" The process actually avails itself of the sugars present in the wood, which through yeast fermentation are converted into ethyl alcohol and carbon dioxide, the mechanism of this reaction being exactly the same as if one were utilizing the sugars available from grain or molasses. It is quite true that methyl alcohol is present in the liquor right from the digesters to the final factionating column, but at this stage it is entirely removed. No established method of analyzing quantitatively or qualitatively has shown methyl alcohol to be present in the ethyl alcohol made at Thorold.

Upon the termination of Government contracts in August, 1945, new outlets had to be found to take care of production. These were successfully established and include most of the grades of denatured and specially denatured alcohol.

Ethyl alcohol quality data are given in Table II for the month of August, 1944, and are essentially the same as at the present time.

TABLE II.—Daily Average Characteristics of Ethyl Alcohol Produced in August, 1944

Residual acidity (%)	0.0009
Permanganate time (min.)	29
Aldehydes (p.p.m.)	25
Fusel oil (p.p.m.)	79
Esters (p.p.m.)	12
Methyl alcohol	Nil*
Proof (Canadian—O.P.)	68.7
Residue on evaporation	0.0009

* Each day below 0.1 per cent, which is minimum determinable quantity.

Position of the Sulfite Liquor Alcohol Industry

After more than three years of successful operation The Ontario Paper Company, Limited, considers that a useful contribution has been made to the paper industry, the industrial alcohol industry, and to the community in general. Today, with a critical food shortage in many lands, every gallon of alcohol manufactured from waste sulfite liquor makes available either half a bushel of grain or two and a half gallons of molasses.

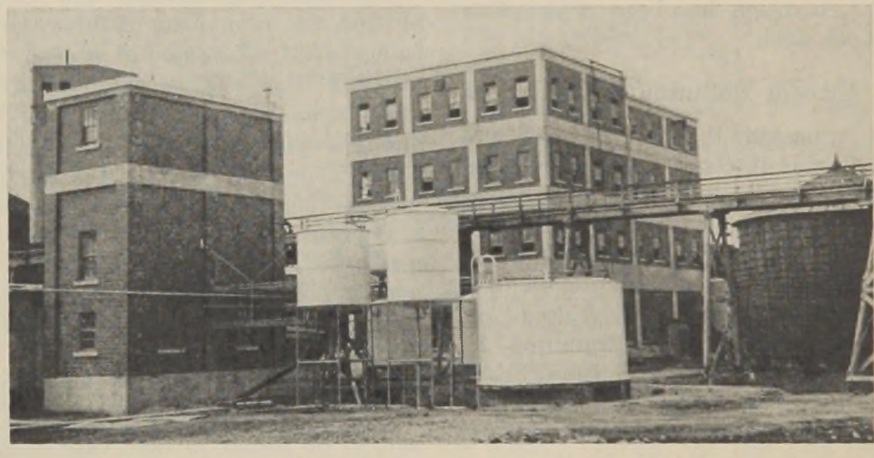

FIGURE 3.—Alcohol plant of the Ontario Paper Co., Ltd., at Thorold, Ont., utilizing sulfite waste liquor.

Only a mere fraction of the sugars now being poured into the streams on this continent are being economically employed. It is estimated that Canadian mills throw away each year about 250,000 tons of sugar. From this amount of sugar nearly 28,000,000 Imperial gallons of ethyl alcohol could be produced. In the United States enough sugars are wasted to produce over 30,000,000 gallons of alcohol per annum. European countries have long realized the potential value of such waste liquor for the manufacture of ethyl alcohol and the current production in Sweden alone is about 80 to 90 million litres (18 to 20 million Imperial gallons per annum.

The normal industrial demand for alcohol would not, of course, absorb such an output, but it is significant to note that Canada and the United States are the only two major countries in which a certain percentage of alcohol is not being blended with gasoline when sold as motor fuel. In view of the diminishing oil reserves it is quite possible that we in Canada may eventually adopt the same procedure. Whatever trend industrial and economic developments may take, one thing is certain, namely, that the production of a useful commodity from waste material is a thoroughly beneficial and economical step, particularly at this time when shortages of raw materials and finished products weigh so heavily on industrial activities.

In conclusion, the writer wishes to acknowledge with thanks the help rendered by Dr. C. A. Sankey, Research Director, The Ontario Paper Co., Ltd., and Dr. M. M. Rosten in making available certain data from their paper "Alcohol from Waste Sulphite Liquor" (6).

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EFFECT OF ALCOHOLIC FERMENTATION AND GROWING OF FODDER YEAST ON B.O.D. OF SULFITE WASTE LIQUOR *

By Richard G. Tyler

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Recent years have witnessed a considerable increase in the number and variety of studies being made to develop methods for the disposal of sulfite waste liquor (SWL) so as to decrease its demand on the dissolved oxygen content of the streams, lakes, and tidal waters into which it is discharged. This is particularly true in those areas where the production of sulfite pulp is a major industry, as it is in the Pacific Northwest, Wisconsin, and in several other parts of the United States and Canada. Its high population equivalent, variously given (1) as from 2,000 to 3,000 persons per ton of pulp, gives some conception of the importance of the disposal problems involved in treating this waste. Plants producing from 100 to 500 tons of sulfite pulp daily would have disposal problems comparable to cities with populations of from 200,000 to 1,500,000. It is obvious, therefore, that the sulfite pulp industry and the various state or provincial stream pollution commissions watch with great interest every attempt to utilize some part of the SWL and thus remove a corresponding part of its oxygen demand from streams already burdened with the effluents from sewage treatment plants.

As one example of the desire of the sulfite pulp industry to solve its waste disposal problems, the pulp mills of the state of Washington in January, 1944, set up a research project at the University of Washington for the purpose of investigating methods for the utilization and disposal of SWL and other wastes produced in the manufacture of wood pulp. Under this project, studies of alcoholic fermentation of the liquor and of the production of fodder yeast have been made. The writer, therefore, welcomes the opportunity to discuss the effect of these methods of utilizing SWL on the B.O.D. of the residual requiring further disposal.

The production of alcohol from SWL utilizes part of the sugar content of the liquor and would, therefore, be expected to decrease the B.O.D. to an extent which depends upon the reduction in sugars and the relative importance of such sugars on the total B.O.D. The SO_2 removed in the process further reduces the B.O.D. Little has been published in sanitary engineering literature as to just how great a decrease in B.O.D. occurs as the result of this process.

Fodder Yeast as a By-product

Recently, the growing of fodder yeast on SWL also has received attention by the sulfite pulp industry throughout the United States as another possible means of utilizing some of the waste liquor and thus minimizing the stream pollution problem by a method which will pay for itself, and possibly provide a profit in addition thereto. In this case, the yeast is living under aerobic conditions whereas in alcoholic fermentation it functions anaerobically. The organism that has been found most effective in the latter process, which is commonly used in alcohol production, is *Saccharomyces*

* Presented at Nineteenth Annual Meeting, Federation of Sewage Works Assns.; Toronto, Can.; October 7–9, 1946.

cerevisiae. In the aerobic process, *Torula utilis*, the fodder yeast, is more frequently used, either in pure culture or mixed with other yeast groups. In the Pulp Mills Research Project at the University of Washington, somewhat better yields have been attained with a mixed culture of *T. utilis* and a smaller mycelial yeast than with *T. utilis* alone.

In considering the effect of these organisms on the problem of stream pollution, it is desirable to estimate the fraction of the liquor's B.O.D. that arises from its sugar content. This matter has been gone into in some detail in a paper by the writer on the B.O.D. of SWL, which paper is now ready for publication. In the present discussion, however, the essential information can be stated quite briefly. SWL is a complex material having 10 to 12 per cent of total solids, a pH of approximately 2.0, and a 20-day B.O.D. of 35,000 to 45,000 p.p.m. Sugars and free SO_2 account for 65 to 75 per cent of this B.O.D.

In various publications concerning the proportion of the sugars utilized by fodder yeast, investigators report as high as 70 to 80 per cent where ample aeration is provided. These percentages check roughly with the writer's findings. It would appear, therefore, that the reduction of B.O.D. would be the product of these two ratios, or 50 to 60 per cent.

Determination of Sugars

One of the difficulties encountered in expressing the amount of sugar fermented by microorganisms arises from the fact that the accepted tests for sugars are unsatisfactory because of interfering substances. What is here referred to as sugars is more accurately designated as reducing substances, and includes pentose along with hexose sugars. The former are not fermented by *Saccharomyces* and account for a large part of the proportion of sugars not utilized by yeast. Free and combined SO_2 will also be included in the reducing substances.

Tests have been devised in an attempt to differentiate between the fermentable and non-fermentable reducing substances, but probably the only accurate way for making this differentiation is by actual fermentation with yeast, and computing the fermented sugars from the CO_2 produced. The figures given above, however, are based upon sugars as determined by the accepted tests for total reducing substances. For estimating B.O.D. removals, this is better than using the fermentable sugars since SO_2 and pentose are also included in it. The percentage removal will obviously be less.

In order to determine which of the usual methods would be best adapted to use on the Pulp Mills Disposal Project, tests were run on a common sample by several of the more frequently used methods, the results of which are given in Table 1. Mr. Avrill J. Wiley, Acting Coordinator for the Sulfite Pulp Manufacturer's Committee on Waste Disposal, Appleton, Wisconsin, kindly consented to cooperate in this test by making a determination of reducing substances using the Somogyi test which has been preferred on the Wisconsin research since it checks more closely the results of fermentation. In this test, preliminary precipitation with basic lead acetate is carried out before determining the reducing substances. The purpose of this procedure is to precipitate the lignin, which is one of the interfering substances.

This table is interesting primarily because it shows the variation in results obtained by the different methods used. Since it was Wiley's experience that the Somogyi test closely checks the fermentable sugars, it would be suitable for our use. It seemed probable that the lead precipitation might remove some of the sugars along with the lignin. In our second series, therefore, Maske made one sugar de-

TABLE 1.—Total Reducing Sugars in SWL by Various Currently Used Methods
(All results in grams per liter)

Sample	Folin Wu Clinical Method (Modified) Maske[1]		Cyanide Method Pollock[2]	Munson-Walker Method (Modified) Peniston[3] and Timbers[4]	Somogyi Method Wiley[5]	
		After Lead Precipitation				Including Sulfite Bound Sugars
Oct., 1944						
Raw	21.6	—	21.6	23.9*	17.42	—
Raw	21.5	—	20.7	—	—	—
Stripped	13.4	—	12.2	15.6†	8.50	—
Stripped	13.1	—	13.6	—	—	—
Jan., 1945						
Raw	19.9	16.16	—	24.63	16.22‡	20.33
Stripped	17.6	14.12	—	22.09	14.17‡	18.61
Fermented	8.1	—	—	9.1	3.85‡	—

[1] William Maske, Associate Research Chemist, Disposal Project, Pulp Mills Research.
[2] Robert Pollock, Chemist, Rayonier, Incorporated.
[3] Q. P. Peniston, Research Chemist, Utilization Project, Pulp Mills Research.
[4] Anna Mae Timbers, Analyst, Utilization Project, Pulp Mills Research.
[5] Averill J. Wiley, Acting Research Coordinator, Sulfite Pulp Manufacturers' Committee on Waste Disposal, Appleton, Wisconsin.
* Average of 10 determinations.
† Average of 6 determinations.
‡ Average of 4 determinations.

termination after precipitation with basic lead acetate and obtained results which closely checked Wiley's determinations for both the raw and stripped samples. These results would be low if any sugars were removed in the precipitation, as above suggested. Since this modification of the Folin Wu method checks the Somogyi test, and since the former had closely checked the cyanide method, it was used on our present research. It has the advantage of simplicity when used with an electrophotometer and can be employed easily in running a series of tests by allowing a 5-min. interval between samples. The Munson-Walker method obviously includes more non-fermentable substances than do the others.

Alcohol Production from SWL

The only plant making alcohol from SWL in the United States, at the present time, is that of the Puget Sound Pulp and Timber Company at Bellingham, Wash. (2). This plant began operations in March, 1945, and has been producing about 6,500 g.p.d. of 190-proof ethyl alcohol. It has a capacity for greater production, however, when the supply of logs is again up to normal. This production of alcohol is equivalent to 22 gal. per ton of pulp.

The SWL utilized contains about 2.5 per cent sugar, of which 1.8 per cent, or 76 per cent of the total sugar, is fermentable. Ther fermentation is carried on at 30° C. and at a pH of 4.5 in a continuous flow process with approximately twenty hours' fermentation time. The continuous flow schedule simplifies the operation so that only three operators per shift are required to run the plant.

Sugar and B.O.D. Removals

The writer has had the opportunity of running tests to determine the effectiveness of the process on the removal of sugars and B.O.D. from the SWL used. The first test series was run on June 20, 1945, or after the plant had been in operation for about three months. A second series was run September 12, 1946, and is, therefore, indicative of plant efficiencies at the present time. These data are reported in Table 2.

The conditions governing alcoholic fermentation have been fairly well standardized but those controlling the oxidation of sugars, as in the growing of fodder yeast, are much more variable. The reduction of B.O.D. obtained by various investigators in the latter field may differ appreciably because of differences of efficiency in the methods used. For example, one of the most important requirements in producing fodder yeast is to supply ample aeration if the maximum yeast production is to be secured. This aeration is provided in a number of ways at the various plants and laboratories. Some of these depend upon mechanical agitation, while others employ air diffusion through porous media. Obviously, the quantity of yeast produced and, therefore, the amount of sugar utilized and B.O.D. removed, will vary with the efficiency of the process used.

Table 2 gives a summary of the data obtained on the removal of sugars and B.O.D. from SWL both by alcoholic fermentation and in the production of yeast. The SWL used in yeast production came from a different mill and had a higher B.O.D. than that used at the Bellingham alcohol plant. The variation in B.O.D. removals obtained by yeast production, as shown in the table, indicates the difference in efficiency that can occur at the same plant under various operating conditions. These oxidation data represent small pilot plant operations.

It may be well to call attention to the fact that commercial centrifugation leaves some yeast cells in the effluent and thus produces less efficient B.O.D. removals than would be obtained if all of the organisms were eliminated. It is obviously more expensive to secure complete yeast removals, and the degree of effectiveness of separation will undoubtedly vary at different plants. Under the present operating schedule at the Puget Sound Pulp and Timber Company alcohol plant, about 98 per cent of the yeast is removed by the centrifugal separators. While the yeast cells in such effluents

TABLE 2.—Removal of Sugars and B.O.D. from SWL by Alcoholic Fermentation and Yeast Production

Date	Sugars in SWL (gr. per l.)	Sugar Removal (%)		5-day B.O.D. of SWL (p.p.m.)	B.O.D. Removal (%)	
		Alcoholic Fermentation	Oxidation		Alcoholic Fermentation	Oxidation
Dec., 1945	24.0	—	72.8	42,400	—	56.7
April, 1946	29.7	—	68.5	39,400	—	32.5
June, 1945	21.8	62.4	—	22,600	40.7	—
Sept., 1946	25.4	62.0	—	22,100	46.6	—
Jan.–Aug., 1946	30.0*	—	65.1*	—	—	—
1945	24.4	76.6†	—	—	—	—

* Average of 5 determinations.

† Average of 4 determinations, computed from CO_2 evolved. Hilda S. Daniels, Assistant Bacteriologist, Utilization Project, Pulp Mills Research.

Note: The above sugar and B.O.D. removals include those removed by stripping.

die in the B.O.D. bottles and appreciably increase the apparent B.O.D., it does not necessarily follow that receiving waters would have an equivalent increase in oxygen demand to meet. These cells might utilize sugars present in the receiving waters or might, in turn, serve as food for fish or other aquatic forms.

Conclusion

Sanitary engineers who have been accustomed to thinking in terms of B.O.D. removals of 90 to 95 per cent as the goal to be attained in efficient waste treatment plant operation might be inclined to think that the 45 to 50 per cent removal of B.O.D. would rule out either alcohol fermentation or yeast growing as a satisfactory method of treatment for SWL. This, however, is far from being the case. More recent methods of setting up standards for stream quality logically demand that the receiving waters be left with specified standards of quality, measured in terms of dissolved oxygen, bacterial content, etc. These may require that the dissolved oxygen in the stream shall not fall below 3 to 5 p.p.m.

For example, the Washington Stream Pollution Commission in 1940 recommended 5 p.p.m. as the minimum dissolved oxygen that should be permitted in the case of one of the local pulp mills which discharged its waste into tide water. With such a requirement, therefore, a given plant having adequate dilution by the receiving stream or tidal estuary to care for the remaining B.O.D. would find that 50 to 60 per cent B.O.D. removal would be all that would be necessary to meet these requirements (3).

In this state most of the pulp mills are located on tide water or on large rivers where it is possible that the removal of approximately half of the load at present put on these waters might prove entirely adequate as a means of satisfactory disposal of SWL. Obviously, each case will require individual study of all of the factors involved. It would appear to be more logical in such cases to set a standard of quality for the receiving waters than to demand a predetermined and arbitrary B.O.D. removal as a basis for acceptance or approval by stream pollution authorities of any proposed waste disposal methods.

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3. One laboratory reports 70–75 per cent overall B.O.D. removal.

THE OPERATOR'S CORNER

THE FERTILIZER MANUAL

Distribution of the manual "Utilization of Sewage Sludge as Fertilizer" marks the second step in the Federation's ambitious program of Manuals of Sewage Works Practice. A costly venture both in labor and money, the fertilizer manual is believed to be a practical and sound investment; it will be to the advantage of every operator to become familiar with its contents so that the book may be of maximum usefulness as a convenient and authoritative reference.

There may be disappointment in some quarters because the manual does not go overboard in making extraordinary claims for the plant nutritional capabilities of sewage sludge. The principal reason that such claims are not supported is that they have not been proven beyond all doubt. By its very conservatism, the manual should find better acceptance by the agricultural authorities who are looked to for guidance by farmers and other potential users of sludge. These authorities have learned to be skeptical of "miracle" fertilizers, and by presenting our product on its real merits, we stand a far better chance to enlist their aid in securing a maximum usage of sludge in applications to which it is best suited.

The same philosophy might well be followed by plant operators in dealing with prospective sludge "customers." Overselling the material, even to a few users, may be of lasting detriment, for if the results are not up to expectations, the bursting bubble could easily bespatter an entire community with doubts. It will be far wiser to encourage the new user to make a trial and observe the results for himself —then if he is pleased he will become a part of your volunteer sales staff!

The sewage works operator in a plant of small or moderate size is primarily concerned with keeping his stockpile within bounds, that is, the development of sufficient local demand to get rid of the sludge as rapidly as it is produced. Every time a user reports a failure—either because of poor growing results or because of an odor nuisance—the local demand suffers a setback. Consequently, the operator should not permit any user to take the sludge unless complete instructions for proper application have been furnished.

The following suggestions apply to the distribution of air dried digested sludge from the average plant of modest size:

1. Encourage the use of sludge for growing forage crops, flowers, shrubs, grass (particularly new lawns) and trees.
2. Recommend application in the late fall and winter unless the sludge can be plowed or otherwise worked into the soil immediately after being spread.
3. Where used for top dressing on existing lawns, recommend that the sludge be finely pulverized and mixed with dry black earth before application. (A sludge disintegrator is a good investment; a modest charge for pulverizing will soon return the cost.) Most of the odor complaints come from springtime applications of lumpy sludge that are left to disintegrate naturally.
4. Advise the user as to the proper quantities to apply (see the manual). Most new users, expecting something remarkable, will apply sludge too sparingly, and are subsequently disappointed.

Many plant operators have prepared printed leaflets for the information and guidance of sludge users. This practice has much to commend it.

Finally, your local or county farm advisor might be glad to direct some large quantity users your way if he knew what your plant has to offer. Your purchase of a few extra copies of the manual and distribution of them to the right people is suggested.

W. H. W.

THE ABC OF DDT *

By Leslie E. West

Chief Engineer, The Joint Meeting, Elizabeth, N. J.; recently Lt. Col., Sanitary Corps, A.U.S.

The fly nuisance which occurs at many sewage treatment plants, and particularly at those plants including the conventional type of trickling filter, is a common vexation to many operators.

It is discouraging, to say the least, when an operator who works conscientiously to hold his plant at high efficiency, to keep his equipment in good running order and to maintain his buildings and grounds neatly and attractively, is confronted with swarms of filter flies in spite of his best efforts. The designing engineer, if at all "operation conscious," will provide for flooding of filters or for chlorination of the applied sewage; or he may select another type of secondary treatment that will not be subject to the fly nuisance.

The reaction of the visiting public to the presence of a large number of flies also is not good. Efforts to impress the visitor with favorable features of the plant are nullified because the "gnats" will be remembered after all else is forgotten.

Up to now effective fly control has been difficult because of the uncertain and unwieldy methods available; the recent introduction of DDT gives the sewage works operator a new and promising weapon.

The Story of DDT

DDT was first synthesized by a German student named Zeidler in 1874. Its potentialities unrealized, the new discovery was shelved as just another curious compound until the Swiss firm of J. R. Geigy, in its search for something to mothproof woolens, included DDT among the many compounds tested. It was noted that DDT possessed definite insecticidal value, and later a man named Weismann of the Swiss Agricultural Experiment Station, in cooperation with the Geigy firm, showed it to have exceptional merit in combating certain agricultural pests and houseflies.

Late in 1942 a sample of insecticide containing DDT was sent from Switzerland to the U. S. Department of Agriculture for evaluation. This procedure is necessary under the Pure Food and Drugs Act before such material can be marketed in the United States. At Orlando, Fla., a group of entomologists headed by E. F. Knipling soon proved DDT to have remarkable destructive effect on body lice, bedbugs, mosquitoes and flies.

In 1942 and 1943 malaria and typhus control were of grave concern to military personnel, and no stone was being left unturned in the search for effective aids. The initial Florida tests of DDT were conducted with caution since the material appeared to be a nerve poison, however, extensive tests by both the Pure Food and Drugs Administration and the National Institute of Health failed to demonstrate any toxic effects from the use of a 10 per cent DDT powder. After extensive field trials involving civilians, troops and prisoners of war, DDT was standardized for general military use of the allied forces against typhus.

The disease, epidemic typhus, long has been one of the war's greatest dreads. After World War I typhus killed hundreds of thousands of Serbians, and history records similar epidemics of the disease in many other wars of the past. But in World War

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II, for the first time, epidemic typhus was almost completely suppressed.

Malaria, dengue, filariasis and yellow fever all transmitted by mosquitos, were other diseases of major military significance in World War II. Applied in various types of sprays, DDT soon proved its worth as a mosquito control measure and the chain of transmission of these diseases was broken.

But now the war is over and DDT has been given its honorable discharge. Among the many applications it is finding in civil life, it promises to be the long sought means of effective fly control in sewage works.

Characteristics of DDT

DDT is a white, crystalline synthetic powder resulting from the reaction of monochloro-benzene and chloral hydrate in the presence of sulfuric acid. The pure material melts at 107° to 108° C., has a specific gravity of 1.6, is relatively inert chemically, and is stable and heat resistant. The pure powder has a tendency to cake when exposed to relatively high humidity, but this does not affect its insecticidal efficiency.

DDT is practically insoluble in water, moderately soluble in certain mineral and vegetable oils and highly soluble in many common organic solvents. The solvent used is usually selected for the particular job.

Effects on Insects

In general, DDT is used as an insecticide by applying it to exposed surfaces upon which insects are likely to alight. Although contact with an insect during the course of application produces death, the greatest value of DDT lies in the residual killing power of the crystalline residue against insects which later alight upon the treated surface. This residue is not readily harmed by sunlight, weather or acid. It does not readily wash off the surface as from rain, but can be removed by mechanical action such as sweeping or wiping with cloths. Tests have indicated persistence of the material on surfaces treated as long as 207 days after application.

When an insect alights on or walks across the treated surface, it acquires (possibly through its feet) a sufficient dose of poison to cause its ultimate death. The signs of poisoning are somewhat delayed after the first contact. Thus a housefly which rests for 30 sec. on a treated surface appears normal for about 40 min., after which it begins to drag its back legs. Then it loses coordination completely, turns over on its back unable to fly, and dies with severe convulsions. The longer the contact time with DDT the shorter the period until death occurs. It is also noted that some insects, such as roaches, have a greater resistance to DDT than others, but both flies and mosquitoes are highly susceptible.

Forms of DDT

DDT is available on the market in several forms; only the three principal ones are discussed here:

(1) DDT powder, dissolving, is the commercial grade of pure DDT from which sprays are made by mixing the powder at the rate of 7 oz. to a gallon of No. 2 oil or kerosene, for the recommended strength of 5 per cent DDT. Ordinarily the powder can be obtained in 5- or 10-lb. cans. This will be the form most commonly used for direct spraying in a sewage treatment plant.

Ordinary fuel oil or kerosene may be used for sprays of 5 to 8 per cent DDT for outdoor use, and refined kerosene for indoor sprays of 1 to 5 per cent strength.

(2) DDT powder, dusting. This is a ready-mixed combination of 10 per cent finely ground DDT and 90 per cent talc or pyrophyllite. This form of DDT is distributed in cans of 2 oz. (for personal use) up to 5 or 10 lb. for special purposes. It is not widely used for fly control.

(3) The third form is called DDT emulsion concentrate. It has been mentioned that DDT is practically insoluble in water, however, if an emulsion of DDT is available, water can be used as a vehicle to distribute the particles to the place desired.

The emulsion concentrate which is recommended for use consists of 25 per cent DDT, 10 per cent Triton X–100 (emulsifier) and 65 per cent Xylene (a solvent which can hold up to 56 per cent DDT). The concentrate is available in 5-gal. containers.

For use with water then, by mixing one part of the concentrate with four parts of water, a preparation containing 5 per cent DDT results, which can be sprayed and used the same way that the 5 per cent oil solution is used. This emulsion has the added advantage, however, that it can be added directly to sewage or water, where oily solutions would not mix.

Insect Pests at Sewage Works

The average sewage works operator these days is much too busy keeping his plant in repair and in running order to do much thinking about entomology, the science dealing with the habits and classification of insects. It may be well at this point, however, to consider briefly some characteristics of the obnoxious insects that infest sewage works, as a preliminary to the discussion of control with DDT.

The flies commonly found in and around the sewage treatment plant are of three types:

First, is the common filter fly, *Psychoda alternata*, a grayish mothlike insect. Some of its characteristics are that it passes through ordinary window screen, it does not bite, but is extremely troublesome by getting into the eyes, ears, nostrils and mouths of both men and animals. Its flight range is limited, usually to not more than a hundred yards, but may be carried further by the wind.

Second is the larger yellow sewage fly, *Eristalis tenax*, sometimes called the drone fly, usually found hovering in the vicinity of neglected settling tanks containing floating sludge, or near grossly polluted bodies of water. Larvae of this fly swim in the water and are called "rat-tailed maggots." They are easily recognized.

The third type, the common house fly, *Musca domestica*, ordinarily of medium size, is a grayish-black in color. It does not bite, and while as a general rule it does not travel more than a thousand yards from its breeding place, it is also carried by the wind, and is attracted to its food supply by odors of decomposition.

Fly control properly exercised should not be directed toward the attempted extinction of the species, but rather toward the reduction in number of adults to the point where the nuisance disappears. The objectives to be sought, therefore, are two: first, reduction in breeding, and second, reduction in the adult fly population.

Reduction in breeding can be brought about by correcting the conditions which cause it to get out of hand, *i.e.*, by reducing the available food supply or by creating an unfavorable environment. It has been usual for filter flies to be combated by flooding to kill the fly larvae; by heavy chlorination to destroy film on the top stone and cause it to slough off; or by continuous high rate application to keep the stones wet to discourage egg laying. Drone flies are eliminated by prompt removal of floating sludge, by keeping tanks from becoming septic and by the judicious use of chlorine. The commonly accepted means for controlling housefly breeding include such measures as the removal of food supply by prompt waste disposal or covering and, in sewage treatment plants, by general cleanliness and the careful control of screenings piles.

Concerning the second objective, reduction in adult fly population, the limitations of swatting, sticky fly paper and the electric fly screen are well known. In the past the effective outdoor killing of adult flies was almost impossible, particularly when conditions which permitted the flies to breed were ignored.

With DDT the picture is changed; once the DDT is properly applied it keeps on working, killing the flies, while the operator goes about his other business. A few days later he suddenly realizes that there are few flies to be found.

Common sense is the best guide in the selection of the method of application of DDT. The habits of the insect pest, breeding places and conditions, the season, the weather, etc., are all factors that dictate how, when and where the insecticide will do the most good.

For example, last year the army conducted some interesting experiments * on filter control at Atlanta, Georgia, using DDT in the filter influent dosed in the same way that chlorine is used.

It is obvious that this type of control work would require the DDT to be used in the form of the emulsion concentrate, and that is what was done. The application of DDT emulsion at a dosage rate of 1 p.p.m. continuously for 24 hours once a week appeared to be very effective in controlling the flies. The material was introduced at the dosing tanks, and it is also reported that no unfavorable effects could be detected in the quality of the filter effluent, or on the life of the filter bed itself.

Recommended Methods of Application

The stability, solubility, residual and other characteristics of DDT make possible the use of many different methods of application and have suggested almost innumerable types of dispersion apparatus. The main point to be kept in mind is the necessity of putting it where it is wanted, without wastage. For general adult fly control in the sewage treatment plant, this will be on walls, ceilings, hanging objects, screen doors and windows, etc. It is also desirable to spray fences, buildings and even vegetation around fly-breeding places so that the flies will be killed after they hatch from their pupal state and crawl upon such objects.

Ordinarily it is recommended that the DDT be used in the 5 per cent solution, with kerosene oil or ordinary fuel oil as the solvent. A good way of applying it to screens is with a clean paint brush. On larger surfaces, such as tank walls, any suitable spray will work, and when spraying is done it should be done not with a fine mist but with a wet type of spray. Such spraying should be done to the point of wetness only, or at the rate of about one quart of DDT solution to about 250 sq. ft. of wall surface.

Environmental temperature bears a definite but varying relationship to the toxicity of DDT against insects. With mosquitoes, the higher the temperature the greater the kill with a given dose of DDT. With the housefly, on the other hand, a dose which kills 99 per cent of the flies at 70° F. kills only 55 per cent at 100° F. Similarly, when flies are knocked down in 40 min. at 70° F., 90 min. are required at 100°.

Toxicity is related in part to the amount of DDT which has been applied to the contact surface. With different types of surfaces, however, a varying amount will actually be left as residue. Thus, when the surface is a freshly painted one, and the material is applied in a kerosene base, the residual effect is much less marked than is the case with a weathered surface.

Apparently the DDT goes into solution in the paint, and as this dries, the DDT is not left at the surface to affect

* See THIS JOURNAL, 18, 2, 208 (March, 1946).

the insects that may alight thereon. The DDT may be applied in varying concentrations of the oil, and it has been found that on wooden surfaces, the same total dose of DDT applied in the form of a 1 per cent spray is less effective than that in a 5 per cent spray. The explanation offered is that the greater the volume of solvent, more of the active agent soaks into the wood and away from the surface. Increasing the surface concentration up to reasonable limits increases the residual effect.

Although the 5 per cent DDT solution in petroleum oils is usually the most practical spray for ordinary fly control, the oil solvent may be objectionable in certain applications. Aqueous emulsions of DDT can be prepared for use where the staining effects or odors of oil might be undesirable.

The toxicity of DDT is unfortunately not limited to harmful insects. Useful insects, such as honey bees, are killed by its application to an area, and will have to be carefully considered when DDT is used for agricultural pest control.

Personnel Hazards

Since DDT is a poison, some evaluation concerning the possible dangers to men and animals had to be made before it could be released for use by the general public. It is significant that no authentic cases of poisoning have been reported in connection with the widespread use of the chemical during the war.

As is customary, the experimental work has been done principally upon animals, and the toxicity of DDT in general follows these lines:

First, DDT has a cumulative effect and, when taken internally at the rate of about 2 mg. per kilogram of body weight, shows some toxic effects. The dusts are *not* absorbed through the skin, but oily solutions are slowly absorbed. The symptoms of poisoning in the animals, which consist of tremors and other nervous manifestations, subside when exposure to the drug stops. The danger from DDT is greatest to the men who are continually employed in using the material for pest control. For them the recommendations are to use the customary precautions against dust or, with oily solutions, to wear gloves and avoid oil-soaked clothing next to the skin *as a habit.* The ordinary user does not need to worry about casual exposure, and will be safe if he follows directions.

Examples of Results

The writer has had several opportunities to observe the effectiveness of DDT in pest control.

Pig pens are noted for their complement of flies, and certain ones in Pennsylvania were excellent examples. The day following application of DDT at this place hardly a fly could be seen and the pens remained free from flies for about three weeks before appreciable numbers began to reappear.

In another case a great many flies were found at an army post in spite of elaborate control efforts. Great care in keeping garbage cans covered and in providing fly traps, electric fly screens, doors and window screens, etc., was all to no avail. A search for the source of breeding revealed that vast numbers were hatching in the partly digested sludge on drying beds at the nearby sewage treatment plant. DDT applied to the walls of the sludge beds promptly solved the difficulty.

At the Elizabeth Joint Meeting plant late last summer DDT applied to screen doors proved very effective in destroying swarms of houseflies which gathered there and entered the building every time the doors were opened.

Conclusion

A great deal is yet to be learned about the methods of application of DDT, its effectiveness and its limitations. While the chemical offers great promise as a means of controlling undesirable organisms, due regard must be given its detrimental effects on beneficial insects, fish and other desirable forms of life. This fact should be kept in mind in using the material.

Magic insect killer that it is, DDT cannot be expected to be consistently effective if employed haphazardly. For each specific problem, be sure to use the DDT in the *right form*, and apply it by the *right method* at the *right time*.

Those who market the various commercial DDT preparations must be cautious in their claims and directions for use, and this conservatism is reflected in some of the warnings printed on the labels. It is just as well that prospective users be admonished to handle DDT compounds with extra care, at least until there is more complete knowledge of its effects on humans and animals.

Sewage works operators confronted with insect control problems now have in DDT a practical and efficient weapon. Learn all you can about the substance, study your problem in detail and then exercise your best judgment and common sense in employing DDT as a remedy.

RAPID METHOD FOR APPROXIMATE LOCATION OF SCUM AND SLUDGE LAYERS IN DIGESTERS *

By Joseph Doman

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A continuous record of the varying depths of the scum, supernatant and sludge layers in a digester is a handy aid to good operation. Such a record not only affords warning that special digestion control procedures may be necessary; it also gives information as to the effectiveness of the measures employed. The method of maintaining this continuous picture of conditions in the separate digester of the Grass Island sewage treatment plant at Greenwich, Conn., may be of interest to other operators.

As all operators know who have made sludge and scum elevation determinations by sampling from the top of a digester, this is a bothersome and messy job which requires an appreciable amount of time. It is a task that is not performed with any degree of enthusiasm, especially under unpleasant weather conditions. The daily sampling and sounding necessary to obtain the desired picture of digester conditions are therefore frequently omitted from routine plant operations, hence a continuous check on digester conditions and the effectiveness of control measures is usually lacking.

The Method

Inasmuch as the Grass Island digester, like many others, is provided with a battery of permanent sampling pipes at different elevations and discharging into a convenient indoor sink, a method has been worked out whereby scum and sludge elevations can be determined daily from a set of samples from these pipes, plus an extra sample from one of the decanting pipes. These data are then plotted to provide a substantially correct picture of digester conditions. The entire procedure is usually completed in about 30 minutes.

In making routine sludge line determinations, samples are required at

* Presented at Spring Meeting, New England Sewage Works Association; Greenwich, Conn.; May 17, 1946.

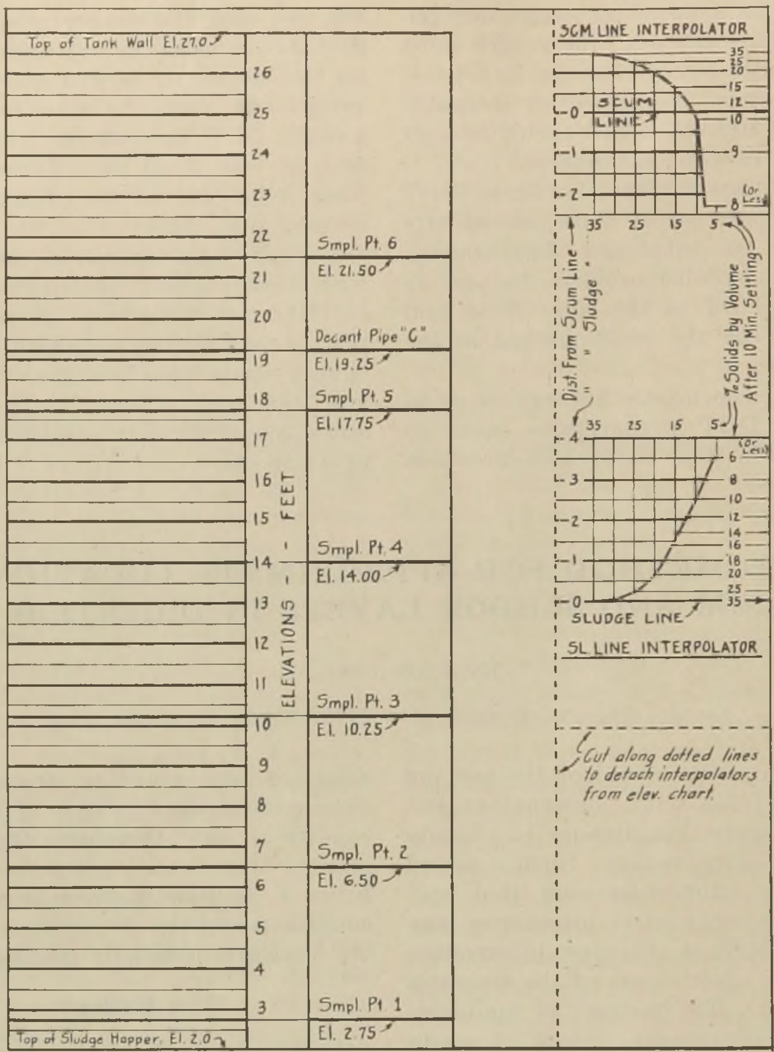

FIGURE 1.—Elevation chart of the Grass Island digester at left.—Scales used for interpolating sludge and scum limits at right.

about 9-in. vertical intervals, or even less, near the sludge line. If such sampling intervals were available in a digester, the sludge line could be determined to within about 2 or 3 in. If sampling intervals of 2 ft. were provided, the sludge line could be estimated to within about a foot of its actual position, merely by proper judgment of the appearance of the samples. At the Grass Island digester, however, the sampling pipes are at vertical intervals of 3 ft. 9 in., and although a system was devised for classifying the appearance of the samples and estimating the positions of the scum and sludge lines from the observed appearance, this was not entirely satisfactory. When checking the levels thus estimated by direct sampling from the top of the tank, the estimated levels sometimes differed by as much as 2 ft. from the more accurately determined levels, although they usually checked within a foot.

In order to obtain better approximations, a series of samples were taken from the top of the tank at 9-in. intervals from the sludge layer to a point about 4 ft. above the sludge line. The per cent solids by volume was then determined for each sample after a 10-min. settling period in 250-ml. graduated cylinders. From these data, a tentative interpolation curve was plotted to show how the distance from the sludge line varied with the different percentages of solids obtained. This curve was later modified to that shown in Figure 1. A similar series of samples and curve, as also shown in Figure 1, were obtained for the vicinity of the scum line.

Instead, therefore, of estimating the location of scum and sludge lines from the observed appearance of the samples, the procedure was changed to obtain the percentage solids by volume after a timed 10-min. settling period in the cylinders and, by use of the interpolation curves, the estimated positions of the scum and sludge lines were obtained between adjacent samples showing thick solids and supernatant. Several check measurements from the top of the digester indicated that the approximated levels were consistently within a foot of the correct elevations, which is regarded as an acceptable degree of accuracy for all practical purposes.

Present Procedure

The procedure now is to collect representative samples at the sink in quart mason jars, bring them to a laboratory bench, shake them thoroughly, transfer them to graduated cylinders, allow them to settle for 10 min. then read the ml. of settled and floated solids, add them together and compute the per cent of solids by volume. The cylinders will indicate the highest sampling point showing sludge and the lowest sampling point showing supernatant. Supernatant is here regarded as liquid containing 35 per cent or less of settled plus floated solids by volume after 10 min. settling.

On a chart (Figure 1) of digester elevations on which the sampling point elevations are plotted, the sludge interpolation chart is placed with the vertical percentage solids as obtained at the lowest sampling point showing supernatant at the elevation of that sampling point. An arrow on the sludge interpolation chart indicates directly the estimated elevation of the sludge line.

A similar procedure is used for estimating the elevation of the scum line. Here the scum interpolation chart is placed with the vertical percentage solids as obtained at the highest sampling point showing supernatant at the elevation of that sampling point, and the elevation of the scum line is read opposite the scum line arrow. Ordinarily, this arrow would be at the 35 per cent solids level, but apparently the scum conditions are affected by gas agitation at the wall of the digester (where the sampling pipes terminate), and probably also by the movement of the floating cover during decanting and pumping. The scum line arrow was therefore arbitrarily dropped 18 in. to give estimated readings which would check within a foot of actual measurements from the top of the tank. The manner in which the digester measurements are recorded is shown in Table 1.

A word of caution is required with regard to the taking of samples. These should always be taken when the digester is in an undisturbed condition from either pumping, decanting or flushing, as erratic results will be obtained if the samples are taken while the digester is in an agitated condition. At the Grass Island plant, the samples are now taken first thing in the morning preceding decanting, thus taking advantage of the overnight quiescent period in the digester. It is also important, of course, to let each sampling pipe flow long enough to make sure that the collected sample actually comes from the digester and not from material deposited in the pipes.

Conclusion

The above procedure for determining the location and thickness of scum, sludge and supernatant layers is not quite as accurate as might be desired, and is really only an operator's short-cut to obtain conveniently information of sufficient accuracy for practical purposes. A better degree of accuracy would undoubtedly be possible if the sampling pipes in the lower half of the

TABLE 1.—Approximate Location of Scum, Sludge and Supernatant Layers, Grass Island Digester, April 7 to May 4, incl., 1946

Day	Observations							Elevations			Layer Thicknesses		
	Per Cent Solids by Volume						Dist. Top Wall to Top Fltg. Cover (in.)	Btm. Fltg. Cover (ft.)	Scum Line (ft.)	Sludge Line (ft.)	Scum[1] (ft.)	Sludge[2] (ft.)	Super-natant (ft.)
	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. C	Pt. 6							
S 7	No samples.												
M 8	100	20.0	8.8	7.2	10.0	100	28	22.0	19.3	9.5	2.7	7.5	9.8
T 9	100	98.4	11.2	10.0	100	100	24	22.3	17.9	11.8	4.4	9.8	6.1
W 10	100	100	11.6	13.6	17.0	100	24	22.3	18.4	11.8	3.9	9.8	6.6
T 11	100	90.0	9.6	10.4	14.0	100	27	22.1	18.7	11.3	3.4	9.3	7.4
F 12	100	100	11.2	13.6	19.0	100	29	21.9	18.2	11.8	3.7	9.8	6.4
S 13	100	100	9.6	10.4	16.0	100	24	22.3	18.5	11.3	3.8	9.3	7.2
S 14	No samples.												
M 15	100	25.6	6.4	7.2	100	100	31	21.8	20.0	10.6	1.8	8.6	9.4
T 16	100	100	10.4	8.0	10.0	100	19	22.8	19.3	11.2	3.5	9.2	8.1
W 17	100	100	11.2	11.2	33.0	100	20	22.7	17.8	11.8	4.9	9.8	6.0
T 18	100	97.2	7.2	6.4	14.0	100	22	22.5	18.7	10.8	3.8	8.8	7.9
F 19	100	100	12.0	12.0	100	100	27	22.1	17.5	11.9	4.6	9.9	5.6
S 20	100	100	6.8	8.0	14.4	100	29	21.9	18.7	10.7	3.2	8.7	8.0
S 21	No samples.												
M 22	99.2	98.0	4.8	5.6	25.0	100	32	21.7	17.8	10.5	3.9	8.5	7.3
T 23	100	100	6.4	7.2	11.0	100	16	23.0	19.2	10.6	3.8	8.6	8.6
W 24	100	100	8.0	9.6	13.0	100	32	21.7	18.8	11.0	2.9	9.0	7.8
T 25	100	100	7.6	6.4	10.0	100	27	22.1	19.3	10.8	2.8	8.8	8.5
F 26	100	100	4.0	6.4	10.0	100	45	20.6	19.3	10.5	1.3	8.5	8.8
S 27	100	100	7.2	6.4	100	100	28	22.0	20.0	10.8	2.0	8.8	9.2
S 28	No samples.												
M 29	100	100	4.0	3.2	10.0	100	27	22.1	19.3	10.5	2.8	8.5	8.8
T 30	100	100	5.6	6.4	11.0	100	34	21.5	19.2	10.5	2.3	8.5	8.7
W 1	100	100	7.2	6.0	8.0	100	20	22.7	21.5	10.8	1.2	8.8	10.7
T 2	100	100	5.6	4.0	6.0	100	21	22.6	21.5	10.5	1.1	8.5	11.0
F 3	100	100	8.4	6.8	11.0	100	21	22.6	19.2	11.2	3.4	9.2	8.0
S 4	100	100	12.0	10.0	10.0	100	15	23.1	19.4	11.9	3.7	9.9	7.5
Ave.	—	—	—	—	—	—	—	—	—	—	3.1	9.0	8.1

[1] Scum thickness is below bottom of floating cover at outside edge.
[2] Sludge depth is above top of sludge hopper (elev. 2.0).

digester were spaced vertically not more than 2 ft. 6 in. apart and in the upper half not more than 2 ft. apart.

If this spacing is employed by designers, it will permit the operator conveniently to obtain daily scum and sludge line locations either from observation of samples taken indoors or from the per cent solids test on such samples. This convenience in obtaining necessary digester control data, which would otherwise be omitted, is well worth the added cost of several additional sampling pipes. It is also suggested that sampling pipes be located at least 10 ft. from decanting pipes.

For valuable assistance in connection with this work, acknowledgment is hereby made to Joseph P. Blackett, Chief Operator of the Grass Island sewage treatment plant.

AN EFFECTIVE TEMPORARY SEWER PLUG

By Richard F. Clapp

S.A. Sanitarian (R), Sanitary Engineering Division, USPHS

To run a check on suspected infiltration into three blocks of sewer owned by the Federal Public Housing Authority in National City, Calif., it was found necessary to plug thoroughly two 12-in. sewers flowing into the line in question. A number of methods to stop the flow were tried without success because of the irregularly shaped openings of the sewer ends at the manholes, and because of very considerable sewage flows which were found even as late as 2 A.M. Eventually, the idea of trying a small solid disk wheel equipped with a pneumatic tube and tire casing was conceived by Frank T. Wigley, San Diego FPHA Area Maintenance Supervisor. The wheels used were 12 in. in diameter, and were taken from a power lawnmower. The tread had been worn from the tires, giving it a smooth bearing surface of approximately 3 in. width.

Assembly of the device is shown in Figure 1. To plug the hole in the center of the wheel, a threaded bolt was set in the hole and a nut and gasket threaded on one end. Another nut and gasket were then threaded on the other end to complete the seal. An eye nut was screwed onto the end of the bolt which projected into the manhole. A rope was tied through this eye to facilitate removing the tire from the manhole at the end of the check. The valve was removed from the valve stem of the tire and a piece of rubber hose long enough to reach well beyond the top of the manhole was screwed onto the valve stem. At the end of the flexible hose, which reached above the manhole, another air connection and valve was inserted. This was then connected to an ordinary tire pump.

In placing the plug in the sewer, there was sufficient flexibility in the tire casing to permit it to pass the irregular sewer opening into the manhole. The tire was then turned at right angles to the sewer and inflated from the surface. This completely checked the sewage flow and was found during the test to hold against a very considerable pressure head which built up behind it. As a factor of safety during the test, however, shoring was placed against the wheel to insure that it would be held in position. At the end of the test when the shoring was removed, the inflated tire was still found to remain in position. To remove the tire, the air was released

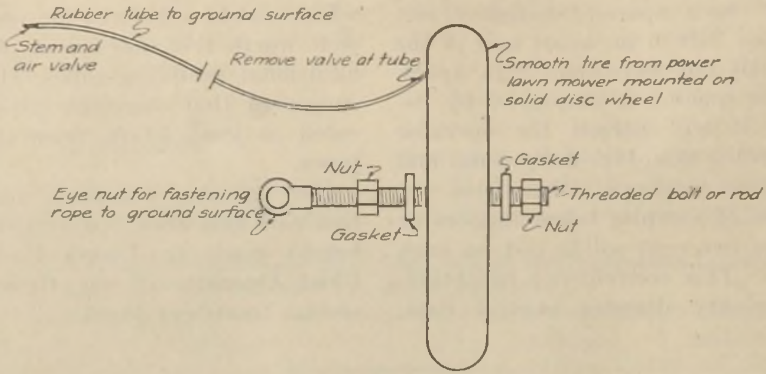

FIGURE 1.—Assembly of sewer plug made from disc wheel and tire.

from it through the valve at the surface and the tire was then forced out by the pressure behind it and was retrieved by the rope which was fastened through the eye bolt.

From this experience, it would seem that this is an economical and very effective method of plugging sewers, and could be of value in infiltration studies and sewer repairs. The plug may also be useful in connection with flushing operations. Because of the variety of small pneumatic wheels available on equipment such as wheelbarrows, motor scooters, and the like, it is believed that this method of plugging could be applied at least to sewers of 8 to 12 in. diameter.

BARK FROM THE DAILY LOG

By Walter A. Sperry

Superintendent, Aurora (Illinois) Sanitary District

Herein we start a new year, a new volume, a new log and with a new fellow logger. We are happy to share the effort of making "The Daily Log" interesting and useful with W. W. Mathews, Superintendent of the Gary, Ind., plant, and we extend him a cordial welcome. We are sure he joins us in wishing an efficient and trouble-free New Year to our readers. It should be remembered, however, that David Harum said, "A few fleas are good for a dog—it keeps him from meditating too much on the fact that he is a dog."

Apropos of all this, we are sure that every operator will find solace in the following anonymous quotation; it is a good philosophy with which to start the New Year:

"The rain it poured, the sea it roared,
The sky was draped in black.
The old ship rolled, she pitched and bowled
And lost her charted track.

"O dear! O dear! Sir, will it clear?"
Loud wailed the dame on deck.
As they heaved the lead the skipper said,
"It always has by heck!"

July 1—One of the great men to whom water and sewage workers owe much is Clemens Herschel. In 1906 he developed the hydraulic studies of Giovanni Battista Venturi, an Italian professor of physics of the 1700's, into the now indispensable Venturi meter. We have always admired the low-head type of meter with the water columns and floats directly connected to the register. Its accuracy is so readily checked that one has great confidence in its performance.

Recently, however, our meter threw a tantrum not previously observed in sixteen years. The flow indicated was about one million gallons low. After some days spent in checking and hunting it was found that a hard incrustation of accumulated sludge inside the float tube was interfering with the movement of the float. It took some ingenuity to clean the tube and flush it but now the accuracy of the meter has been restored.

July 10—Here is a suggestion about insulating that may prove helpful to others. A 5-in. steel pipe line 50 ft. long conveys sludge from our sludge meter to the primary digester. The pipe runs at an angle through the wall of the meter room to the outside, and is half above ground and half buried so that protection from freezing is required. The old line has rusted out and the exposed part had been insulated with the usual pipe covering, while the part below the ground was encased in a wooden box. The whole scheme was unsatisfactory because water and melting snow leaked into the part below ground.

In planning the new line, the trench was dug down to the roof of the digester with the intention of building a concrete box, sealed to the roof of the digester, to be filled with dry sand and sealed with a concrete cover. The plan, however, was difficult and time consuming—even though we are told it was a good one. It was abandoned for the simpler solution of applying a heavy coat of "No-Drip"—a water emulsion of asphalt containing ground cork, and having excellent insulating qualities. It was applied in successive layers to a thickness of ¾ inch. Finally the pipe was wrapped and wired with two thicknesses of roofing paper and the trench filled. Thus we accomplished a complete and lasting protection for the pipe with very little effort.

August 1—The war is over. Tires can be had—if one knows the right people. Gasoline does not have to be accounted for. Folks again can travel by land, sea and air. Not only can neighboring operators drop in to talk things over but sanitation authorities from other lands are beginning to call. Chicago is a focal point of great interest to these gentlemen, who are undoubtedly awed by that city's great plants and problems.

Many of these men, however, are keenly interested in plants of smaller size and during September Aurora was privileged to greet and entertain the following visitors from afar: Bjorn Romson, Civil Engineer, Stockholm; Sweden; Pedro Dolona, Engineer, Guayaquil, Ecuador; Dr. T. R. Bhaskaran, All India Institute of Public Health and Hygiene, Calcutta, India; Luis Romos, Chief Engineer, Sewage Section, Water Works and Sewage Service, Puerto Rico.

August 7—Once in a while a salesman calls to present a tool of such obvious merit and cleverness that it sells itself. We have just bought an item that is worth describing (even though we get no commission). It consists of an ingenious arrangement of a clamp, cutter and screw for drawing up a stainless steel band that comes in 100-ft. strips, ⅜ to ¾ in. wide by ⅛ in. intervals. Also, there is a corresponding set of buckles through which the band is threaded and secured. It is called a "BAND–IT" and is made by the Band-It Company, Denver 5, Colo. The cost of the outfit, including a 100-ft. roll of band and 100 buckles, is about $23.

The versatility of the kit is amazing. It so happens that in one week of use ours was paid for ten times over. One of our men was arrested and fined because of a noisy muffler on his car. A sheet of galvanized iron and two bands completely restored the muffler. A downtown pump in a deep caisson developed a hole in the check valve. Removal, welding and replacement of the part would have been a long, hard and expensive job, but ten minutes, a piece of ⅛-in. sheet rubber packing and a band made a good repair. A similar hole in the air drome of a sludge pump was soon fixed. The outfit is excellent for making hose connections of any diameter.

August 10—The most difficult, most interesting and most important job for 1946 was the cleaning and repairing of our No. 1 digester. In 1936 the unit was altered by raising the overflow and changing the piping so as to make it function as a first stage digester, using the other two as secondary digesters. All three of these tanks are 50 by 50 ft. square and 16 ft. deep. They are equipped with fixed covers and with Dorr truss-supported mechanisms. The discharge pipe to the sludge beds is located 4 ft. above the bottom of the tank, thereby leaving 10,000 cu. ft. of contents that can only be removed by pumping.

Because of a broken casting, the scum arm on the No. 1 digester was not operating when it was put in service as a first stage unit, but despite the loss of this desirable feature the digester has done good work for ten years. During this period the only sludge removed was that transferred.

Late in 1945 it was noted that only 50 per cent of the total gas was being produced in the first stage, instead of the 75 per cent normally obtained. We immediately suspected that grit and inert material had finally filled up the lower 4 ft. of the tank because of our practice of transferring sludge from mid-depth rather than the bottom. Exploratory samples confirmed our suspicions. Having no means for sludge recirculation, it was obvious that a thorough cleaning was in order. The job was started June 24 and finished today.

After running all the sludge possible to the beds, the gas dome was removed and the cover of the inspection manhole opened. This started enough circulation of air to purge the digester of gas. The process was hastened by keeping an electric fan running in the gas dome opening till the digester was completely emptied. The sludge in the bottom was so inert that practically no gas formed during the month required to pump the tank down.

The material in the bottom of the tank was almost solid enough to stand on, and we were fearful that it could never be pumped out. An attempt to use a ball valve pump located on top of the tank was unsuccessful because the suction could not be maintained owing to frequent shutdowns to clear the valves of small sticks and stones.

We then rented a flap valve diaphragm pump, in which the valves were large enough to pass an object 4 to 6 inches in size. Instead of placing this pump on top of the tank, it was located about 10 ft. below the top on a platform between the tank and the sludge beds. This produced a syphon effect that helped keep the pump primed and greatly reduced the suction head. The large flap valves not only passed the sticks but very heavy sludge as well. By constantly jetting and at the same time moving the suction end of the hose about in the softened pools of sludge, the job was finally completed.

A near tragedy occurred during the pumping operation when a high school boy attending the pump and jet was knocked to the ground by a bolt of lightning during a sudden thunder shower. Although he was badly scared (as were we) he soon recovered his nerve and went back to work.

One observation of interest was that the four 1¼-in. wrought iron heating coils carried on brackets on the walls of the tank appeared to be in excellent shape after their 16 years of service. No brackets were loose and but little corrosion was evident. The toughest mechanical job was that of replacing the 200-lb. castings for the scum arms at the top, and a similar casting (found cracked) for the plow arms at the bottom.

The tank was seeded with sludge from the secondary digesters and filled with raw sewage. Gas production began immediately. (Almost 80 per cent of the total gas production has taken place at the first stage digester since it was cleaned.)

August 25—As we were setting up the routine B.O.D. dilutions this morning, in walked a fine looking family group of four. "Are you *the* Mr. Sperry? We read all your articles," was the flattering opening remark.

And so we became acquainted with Superintendent Glen Jenks and family, of Sheridan, Wyo. An entire morning was pleasantly passed in talking shop.

September 3—Both the superintendent and his men derive real satisfaction from a difficult job that is well planned and successfully completed. Such an experience builds confidence and good will.

The incinerator at the Aurora plant was installed in 1932 and, barring minor repairs, it has stood up well and given excellent service. On top of the brick structure there is a large sheet iron box to receive, drain and store wet screenings until they are fed to the burning grates below through a hole at the rear of the box. The hole can be closed with a cast iron plug attached to a wire rope and weight. Finally this box completely rusted out and the incinerator emitted smoke and odorous gasses.

We managed to keep the incinerator in service until the end of the war made it possible to secure the sheet iron necessary to give it a thorough overhauling. This time the back and sides were laid up with fire brick, well supported by the angle iron frame, which was reinforced with additional angles and completely rewelded. The feed door in front, the top and the drain pan were made of 7 gauge sheet iron, replacing the 12 gauge sheet originally used. A ventilating pipe cut into the top of the box was vented into the stack to bleed off smoke and fumes. New furnace doors, frames and grate bars (two years on order) and some minor brick repair completed the job. The incinerator, as rebuilt, works better than ever and not in our lifetime will the upper part need rebuilding.

An old furnace man gave us a tip on laying fire brick that we pass along. The brick are thoroughly soaked in a tub of water before being dipped into the fire clay cement slurry and laid. The water in the cement is not absorbed by the brick, giving a strong bond.

September 12—Providence needs to be kind to the operator that is not a Jack-of-all-trades, including clock repairing. We had our turn today when the 5,000 cu. ft. per hr. gas meter stopped recording only eleven months after we had taken it down for a complete overhauling.

It was a four-man job to disconnect and load this meter into the truck so we decided to investigate first. After opening the waste trap on the digester and connecting the gas pressure tank to the engines, the meter was cut out and the top removed. The diaphragm and valve mechanism were intact, but the small bronze rod that transmits the valve motion to the counter head corroded until it broke off in the stuffing box. The counter clock was a crusted mass of copper sulfide scale, due to a slight leakage through the stuffing box. Some of the small pinions were filled with the same scale and one large wheel had broken loose from its shaft. Bad as it looked, only a half day was required for three of us to clean up the meter, solder the broken parts and restore it to service. It works, too!

October 6—Long before the time for the Toronto convention we made arrangements to make the trip by plane. It was our first flight and greatly enjoyed—will surely try it again.

Imagine our pleasure, on arrival at the Chicago airport to find that Prof. Babbitt of the University of Illinois, L. S. Kraus of Peoria, Walter Kunsch of Urbana and Henry Riedesel and Dennis Johnson of Rockford were all scheduled for the same flight. All of which made the experience so much more enjoyable.

INTERESTING EXTRACTS FROM OPERATION REPORTS

Conducted by LeRoy W. Van Kleeck

Annual Reports of Sewage Disposal and Garbage Reduction of the City of Indianapolis for the Years 1942, 1943 and 1944 *

By Don E. Bloodgood, *Superintendent in 1942,* and W. H. Frazier, *Superintendent in 1943 and 1944*

1942 Report

Industrial Inspection and Interceptor Connection Maintenance

There were 1,337 inspections made at filling stations, meat packing plants and dry cleaning establishments. Of the 436 violators, recalls were made on 265 and of this number 171 had made the requested corrections. The cooperation of the larger companies is very gratifying and, of course, is the most sought after.

A thorough inspection of interceptor connections (connections from combined sewers to intercepting sewers) has been maintained throughout the year. There were 233 stoppages removed during the year. The inspections were made at intervals of only a few days, so that the overflow of sewage into the various streams was kept at a minimum. (*Abst. note:* Another city to share honors with Buffalo, N. Y., for a necessary job too frequently neglected by municipalities.)

Primary Tank Skimmings

Some difficulty has been experienced in pumping the skimmings from the primary tanks. The grease apparently forms a coating on the inside of the sludge line. This condition was found to be particularly troublesome in the venturi throat used for measuring primary sludge pumpage. Some hopes are being held out for the remedying of this condition by use of steam. Results to date are not conclusive. (*Abst. note:* Rodding of lines generally proves to be the best remedy.)

Secondary Treatment

As in the past every effort was made to remove as much B.O.D. as possible before discharging the effluent to the stream, but with the increases in sewage volume and sewage concentration, it was impossible to treat all of the clarified sewage by the activated sludge process with the present plant capacity. The amount of sewage treated by the activated sludge process was the maximum that could be handled and still give plain aeration treatment to the balance of the sewage flow.

At the end of the year, it was apparent that such diffuser plates as could be removed for cleaning would have to be given the caustic-hydrochloric acid washing before they would be suitable for aeration during the coming year.

* For previous extracts see This Journal, 10, 1, 137 (Jan., 1938) and 11, 3, 542 (May, 1939).

Past experience indicates that diffuser plates should be cleaned every two years.

For the months of March, April and May, practically no sewage was treated by the activated sludge process. The reason for this is quite apparent when looking at the river flows for these months. The policy has been to give the degree of treatment, in the cooler months, necessary to maintain the river in a satisfactory condition and not allow the accumulation of sludge banks to give trouble during the low water of the summer months. Though the plant has adequate capacity to give the necessary treatment for about 8 months of the year, it does not have sufficient capacity to treat all of the present concentration of clarified sewage to the degree necessary to keep the stream in a respectable condition during the other four months.

Sludge Disposal

The quantity of digested sludge removed from the lagoons was considerably lower than it has been for the three previous years. No doubt the tire situation and gasoline rationing had much to do with the amount of sludge hauled by the market gardeners. The sludge was in good condition and each load that was hauled away represented a goodly amount of solid material. Though the sludge lagoon capacity seems adequate for the present, the sludge disposal problem can easily become critical in a comparatively short time. Should it develop that in the next year or two that little or no sludge is hauled away by the market gardeners, the sludge disposal problem could become serious.

River Data

The flow in White River did not reach a critical low until October and the cool weather, giving reduced biologic activity, assisted in eliminating any adverse effect upon aquatic life in the stream. This higher river discharge was greatly appreciated in view of the fact that the increased load on the plant necessitated the discharge of more putrescible material to the stream than can be handled by the stream at flows which are not unusual.

Work done several years ago on the amount of B.O.D. that can be handled by the stream indicated that in order to maintain the required amount of oxygen in the river, it would be impossible to discharge more than 8,000 to 10,000 lb. of B.O.D. into the stream each day. To meet this requirement for a flow of 70 m.g.d., which was not unusual for the summer of 1942, it would require the discharge of a plant effluent not exceeding 13 to 15 p.p.m. of B.O.D. The average daily discharge of B.O.D. for the minimum month was 27,400 lb.

1943 Report

Industrial Inspection and Interceptor Connection Maintenance

A total of 1,317 inspections were made this year at filling stations, garages, meat packing plants, canning plants, poultry houses and dry cleaning plants. A total of 417 violations were found; 291 recalls were made, and 193 corrections were found to have been made. This record looks good but actually the violations by the large companies have been more numerous than in past years. This can no doubt be attributed to increased production plus the shortage of help.

The 120 connections between the combined sewers and the intercepting sewers have been inspected regularly for stoppages. During the year 190 were found and removed. .

Primary Treatment

Thirty-eight per cent of the suspended solids were removed from the raw sewage by primary treatment. This would be considered poor efficiency for a primary plant of modern design, however, since 40 per cent of the raw sewage passes through fine screens affording a solids removal of about 15 per cent and the remaining 60 per cent passes through primary settling tanks with a detention time of approximately 30 min., it is probably all that can be expected.

Skimmings from the primary settlers are still being pumped to the sludge lagoons. Considerable trouble has been experienced, however, with grease which coats the inside of the pipe line. A bonnet was removed from a valve on this line and inspection revealed that the 6-in. pipe was lined with a 1-in. layer of grease, leaving an opening equivalent to a 4-in. pipe. Steam has been turned into this line several times but, since there are only a few hours each day that the line is not being used, only about the first four or five hundred feet can be heated. Too, there are no expansion joints in the line and it usually breaks when heated. No doubt another method of disposal will have to be worked out.

Secondary Treatment

Sewage was treated by the activated sludge process in only ten of the 21 aeration units during the critical months. The plain aeration of sewage (without return sludge) was practiced in the remainder of the plant. It was impossible to treat all of the sewage received from the primary process by the activated process. This was no doubt in large part and possibly wholly due to the insufficient capacity of the primary clarification plant, which made it necessary for the secondary treatment plant to handle a very strong sewage.

The air diffuser plates were removed from two aerators for cleaning. Of the 2,744 plates removed, 258 were broken either while being removed or during the washing process. These plates were cleaned by boiling them in 6 per cent caustic for 5 hours, washing with water and blowing with air, and then submerging them in 10 per cent muriatic acid for about 18 hours, after which they were washed with water and blown with air again. This is the second time that the plates have been removed and cleaned. Cleaning restored them to about 50 per cent of their original permeability.

Sludge Disposal

Sludge was hauled only during the first three months of the year. No sludge was hauled during the fall and winter months because the crane, normally used to dip sludge, was engaged in loading coal for the power plant because of the coal mine strike.

The digestion lagoons are rapidly becoming filled and something will have to be done in the very near future. This condition has been made more critical by the discharging of ground garbage into the lagoons. The garbage reduction plant was not able to process all of the garbage because of condemned cookers.

1944 Report

Industrial and Interceptor Inspections

A total of 1,459 inspections were made at filling stations, garages, meat packing plants, canning plants, poultry houses, dry cleaning establishments, etc. Violations numbered 544; 332 recalls were made and 205 corrections were found to have resulted.

The 120 connections between the combined sewers and intercepting sewers have been inspected regularly for stoppages and 198 such stoppages were found and removed.

Primary Treatment

Three of the revolving fine screens have been completely overhauled. New shafts, bushings, and sprockets were installed and the new sprockets were located on the opposite end of the screen from where they have been been. Material has been ordered and progress is being made in the overhauling of the other six screens, which need it badly.

As no effective method was found to

TABLE 1.—Summary of 1942, 1943 and 1944 Operating Data at Indianapolis, Ind.

Item	1942 Average	1943 Average	1944 Average
Estimated 1942 population	404,000	416,000	416,000
Sewage flow (m.g. per month)	1,826.72	1,765.48	1,907.58
Sewage flow (m.g.d.)	60.06	61.59	63.26
Sewage flow primary treated (per cent)	61.0	59.6	60.7
Grit (cu. ft. per m.g.)	1.69	1.35	1.05
Raw sludge (lb. dry solids per m.g.)	1,410	1,200	1,093
Solids removed by primary tanks, per cent	44	38	35
Activated sludge and plain aeration treated sewage (m.g.d.)	60.06	61.34	63.26
Lb. solids removed by secondary treatment per m.g.	1,597	1,274	1,334
Activated sludge treatment:			
Flow treated (m.g.d.)	22.67	13.54	20.8
Air (cu. ft. per gal.)	1.45	1.68	1.52
Air (cu. ft. per lb. B.O.D. removed)	847	1,060	1,095
Aeration period (hr.)	8.28	8.97	8.9
Settling rate (gal. per sq. ft. per day)	825	781	—
Lb. dry solids removed per m.g.	1,764	1,764	1,908
Plain aeration treatment:			
Flow treated (m.g.d.)	42.23	53.36	51.92
Air (cu. ft. per gal.)	0.49	0.53	0.59
Air (cu. ft. per lb. B.O.D. removed)	544	623	577
Aeration period (hr.)	6.43	7.9	7.45
Settling rate (gal. per sq. ft. per day)	1,284	1,489	—
Lb. solids removed per m.g.	1,525	1,145	1,474
Ash (per cent)			
Primary sludge	30.9	30.3	28.4
Plain aeration sludge	35.0	32.3	32.1
Activated sludge	34.0	32.7	35.1
Suspended solids:			
Raw sewage (p.p.m.)	386	366	364
Settled sewage (p.p.m.)	215	224	234
Activated sludge effluent (p.p.m.)	7	13	5
Total plant effluent (p.p.m.)	41	50	44
Primary sludge (per cent)	7.04	6.24	5.3
Plain aeration sludge (per cent)	4.44	4.24	3.8
Return sludge (per cent)	0.92	0.89	0.92
Mixed liquor (per cent)	0.24	0.26	0.28
Chloroform soluble matter:			
Settled sewage (p.p.m.)	46.3	47.1	—
Primary sludge (per cent)	19.5	21.4	—
5-Day B.O.D. (p.p.m.):			
Raw sewage	252	247	262
Primary effluent	182	181	193
Plain aeration effluent	103	92	106
Activated sludge effluent	9	13	10
Effluent to river	76	85	81
White River data:			
Flow above plant (c.f.s.)	1,207	1,490	740
D.O. above plant (p.p.m.)	5.99	5.77	6.9
D.O. 6.25 mi. below plant (p.p.m.)	3.98	3.60	1.7
Cost of operation:			
Per m.g. treated, dollars	8.69	9.67	9.81
Per capita per year, dollars	0.47	0.49	0.54
Night soil removal:			
Vaults cleaned per month	150	153	147
Barrels removed per month	3,252	2,499	2,520
Sludge from pits, cu. yd. total year	14,878	10,556	2,592
Sludge index	—	—	103
Aerator loading (lb. B.O.D. per 1,000 cu. ft.)	—	—	25.5

remove or keep the grease from collecting in the sludge discharge line, a large wooden tank 16 ft. high was set up near the primary settling tanks to receive the grease. The pipe connections to this tank are similar to those of an ordinary catch basin. When a quantity of grease collects in the tank it is pushed off into a chute near the top of the tank and drops into a truck. Practically no water is drawn off with the grease. It is then hauled to the sewage plant dump where it is burned. This method of removal has been trouble-free and economical in operation.

Secondary Treatment

Both activated sludge treatment and plain aeration treatment was given the sewage. During September and October the plant was operated half as an activated sludge plant and half as a plain aeration plant.

Sludge Disposal

The digestion lagoons are all full except No. 12, which is dried down for cleaning. Space for waste sludge is obtained only by rotating the feed from one lagoon to another, so each goes through a cycle. It is hoped that there will be sufficient lagoon capacity to handle the sludge until the sewage plant is enlarged, at which time some other means of sludge disposal will no doubt be adopted.

River Data

More pounds of B.O.D. were received at the plant in 1944 than in any previous year, and consequently more B.O.D. was discharged to the river. This heavy load to the river, plus the fact that the average river flow for the last six months of the year was only 140 c.f.s., kept the river in poor condition during the summer months and until the end of the year.

Report of Sewage Purification for the Year Ending March 31, 1945, for the Denton Urban District Council, Denton, England

By Donald H. Barraclough, *Manager*

Tank Treatment of Sewage

Precipitation with lime was again the method of tank treatment; the average dose of lime applied, based on the volume given full treatment, was 7.87 parts per 100,000 as compared with 9.0 parts per 100,000 for the previous year. Some economy in lime usage was effected during the summer months, when liming was restricted to the strongest sewage flows only, and in this way advantage was taken of the capacity of the active biological life in the filters to consume organic sewage matter.

Filtration

All precipitation tank effluent has been given full treatment by filtration, the average dose applied to the filters being 74 gal. per cu. yd. compared with 77.3 gal. per cu. yd. for the previous year. Slight surface ponding occurred in the winter and this was relieved by forking, and moss growths during the summer and autumn were eliminated by salt treatment. Approximately 7.0 m.g. of tank effluent were treated on the land filtration area.

Effluents were generally satisfactory, although there were periods when they were in the "borderline" class, due to the presence of suspended solids. It is not possible to remove these humus solids until the necessary tanks are installed in the extensions scheme.

There was no nuisance from filter flies and the insect *achorutes viaticus* continued to thrive and accomplish useful cleansing of the filter media.

Sludge Disposal

The quantity of sludge produced was lower than the previous year, and all the press cake and air dried sludge was sold for agricultural use. The improved conditions in filter pressing were maintained, the percentage of lime used being lower than in the previous year, while the quantity of wet sludge per press was increased. Press cakes have generally been satisfactory and there has been reduced wear on cloths in consequence.

Small quantities of sludge, totalling 712 tons, were passed to the lagoon for digestion during the year, and were afterwards dried on the experimental drying bed.

(This report did not include a general description of the plant, but the following data give some information on the treatment units.—*Abstractor*):

Primary precipitation tanks—Two in number, having total capacity of 142,644 gal.
Secondary precipitation tanks—Four in number, having total capacity of 696,376 gal.
Storm water tanks—Two in number, having total capacity of 342,893 gal.
Percolating filters—8 circular units and one rectangular unit with a total capacity of 12,672 cu. yd., all 4 ft. 6 in. deep.

Table 2 is a brief summary of the 1944–45 operating data.

TABLE 2.—Summary of 1944–45 Operating Data, Denton, Eng.

Item	Average
Estimated population served	23,000
Daily dry weather sewage flow (gal.)	750,000
No. of premises discharging trade effluents	17
Industrial waste flow in sewers (gal.)	256,700
Cost of operation (pounds sterling)	3,302
Sludge removed from tanks (tons)	8,328
Press sludge cake produced (tons)	1,306
Storm water tanks operated (days)	167
Per cent of sewage flow given full treatment	88.4
Per cent of sewage flow given storm water treatment	11.6
Tank cleansing operations (times per year):	
Primary tanks	44
Secondary tanks	30
Storm water tanks	17

Annual Report of the Buffalo, New York Sewer Authority for the Year 1944–1945 *

By John W. Johnson, *Works Supt.*, George F. Fynn, *Chief Chemist*, and Cecil F. Seitz, *Chief Engineer, Sewers Dept.*

Improved Grinding Teeth

Material removed from the ¾-in. bar screens was ground and returned to the sewage flow. With additional test runs it was found that specially heat-treated carbon steel grinding teeth produced more satisfactory results than those tipped with expensive alloys. Indications are that even when all metals are again available the former type will be used because the latter failed so often at the junction between the cutting edge tip and the holding stub.

Pipe Clogging from Grit

Warm weather in March caused all of the record accumulations of the winter snow to melt within a short space of time. Runoff therefrom brought a vast quantity of sand and grit to the treatment works. Finer particles of sand, which carried over to the sedimentation tanks, plugged the suction lines and two tanks had to be dewatered in turn so that the lines could be cleared. Exerting water pressure on one line caused a vertical section of the 8-in. pipe to burst. When sewer cleaning rods and augers failed to make headway, a water power turbine cutter succeeded in freeing the obstruc-

* For previous extract see This Journal, 18, 319 (1946).

tion. As a means of reducing this carry-over from the grit chambers, the discharges from the main pumps were throttled and some benefit was noted.

Operation of Sedimentation Tanks

Removal of suspended solids from the sedimentation tanks was over 20 per cent greater than during the past seven years. Raw sludge pumped from them averaged 160,000 gal. of 7.9 per cent solids per day. Oil in the sewage again created problems throughout the year. A new type of culprit made its appearance as a heavy brown mass on the surface. Samples taken gave high volatile values and extractable ether was high; the substance was also infested with maggots. Determination of the offending industry was difficult, but by the end of the year the sewer patrol had localized the source to one district and was proceeding to search further.

Raw Sludge Pump Performance Improved

Tests with the raw sludge plunger pumps confirmed the fact that better performance and service were obtained with plungers of smaller diameter. Consequently, eight of the units were reconstructed with heavier housings, pistons, drive rods and bearings, and pistons were reduced 2 in. in outside diameter.

Pipe Clogging from Tank Skimmings

Removal of tank skimmings still continued to give trouble in the operation of plunger pumps and through the discharge piping. Satisfactory equipment to handle such material is limited to a few types or methods which were being investigated at several other plant locations. It is expected that by next year some type can be secured which will remove the scum more satisfactorily. The coating of grease on the walls of the discharge line is still being checked by frequent steaming of the line to a degree which will melt the deposit. This leaves much to be desired because of the distortion which occurs when a 600-ft. cast iron bell and spigot line is subjected to heat ranging from 150 to 180° F. This procedure had

TABLE 3.—Summary of 1944–45 Operating Data, Buffalo, N. Y.

Item	Average
Estimated population served	600,000
Sewage flow (m.g.d.)	145
Total cost of operation (dollars)	443,558.54
Cost per m.g.	8.40
Cost per m.g. excluding pumping	6.99
Suspended solids:	
Raw sewage (p.p.m.)	222.0
Effluent (p.p.m.)	121.0
Removal (%)	45.5
pH raw sewage	7.1
B.O.D.:	
Raw sewage (p.p.m.)	134.0
Effluent (p.p.m.)	97.0
Removal (%)	27.6
Chlorine demand:	
Raw sewage (p.p.m.)	4.6
Supernatant liquor (p.p.m.)	331.0
Total demand (p.p.m.)	4.91
Presumptive Coliform bacteria:	
Raw sewage (1,000 per ml.)	90.9
Effluent (1,000 per ml.)	1.83
Grit:	
Cu. ft. per m.g.	2.3
Per cent dry solids	60.1
Per cent volatile matter	39.8
Raw sludge:	
1,000 gal. daily	160.0
Per cent dry solids	7.9
Per cent volatile solids	64.2
pH	6.4
Digested sludge:	
1,000 gal. daily	75.0
Per cent dry solids	8.7
Per cent volatile solids	57.8
Supernatant liquor:	
1,000 gal. daily	134.0
Per cent dry solids	3.0
Per cent volatile solids	53.0
pH	7.0
Digestion tank temperature (F.°)	94.4
Sludge gas:	
1,000 cu. ft. produced daily	556.5
Per cent carbon dioxide	30.1
Cu. ft. per capita daily	0.93
Cu. ft. per lb. vol. matter added	9.6
Incineration:	
Tons wet sludge cake daily	82.0
1,000 lb. dry solids daily	61.0
Per cent volatile matter	49.3
Per cent CaO (dry basis)	11.32
Per cent ferric chloride (dry basis)	2.44
1,000 lb. dry ash daily	26.1
Per cent volatile matter in ash	7.0

to be curtailed when a portion of the line buckled so badly that there was danger it might fall from its overhead position. Under new operating routines the discharge line is flushed for several minutes after each pumping period and velocities when pumping sludge or flushing are kept at a maximum to prevent settling within the line. This method has worked exceedingly well and steam cleaning of the line was necessary only once in the last six months.

Sludge Disposal

Effects of continuous recirculation of supernatant liquor were apparent in the reduction of scum solids through the four tanks.

On a hot Sunday in June, during a weekend shutdown, the conveyor belt which delivers sludge cake at the rear of the incinerators caught fire. The cause was traced to radiated heat from one of the furnaces, causing the rubber-covered belt to ignite. Flames which ensued destroyed a part of the belt, electric wiring, buckled some of the steel framework and scorched adjacent painted areas. Automatic fire extinguishers installed over the belt at this point failed to operate and the blaze was extinguished by the fire department. The next day a new belt was installed and other repairs completed so that the following day operations were resumed. The sustained loss was covered by insurance. To avoid a continual contact period during shutdowns it is now the procedure to operate the belt for several hours after shutdown.

Operations of Sewer Patrol

Regular inspections of siphons, intercepting and overflow chambers and manholes, and other appurtenances have continued to be made by the Sewer Patrol, which consists of three men with an adequately equipped truck. There are 244 such points of regular inspection, in addition to 16 gauging stations in trunk sewers. A total of 7,273 inspections have been made by the Sewer Patrol during the past year. In these inspections, connections to the intercepting system have been found completely stopped in 228 instances, with sewage overflowing the weirs to the overflow outlet, and in 36 instances connections have been found partially stopped.

Table 3 is a summary of the 1944–1945 operating data.

Report of Belleville, Illinois Sewage Treatment Works for the Period May, 1941 to April, 1945

By O. G. Ruhmann, *Superintendent*

Plant Description

Belleville's sewer system collects most of the industrial and domestic water-carried wastes produced within the city limits, and discharges them to the municipal sewage treatment plant (operating since February, 1941) where they are treated by separate sedimentation and the activated sludge process. Storm water runoff dilutes the wastes in the sewers and during heavy rains will increase the flow so that some of the diluted sewage is discharged at overflows into Richland Creek and tributaries. A portion of the diluted sewage reaching the plant during rainstorms is discharged to Richland Creek after receiving only primary sedimentation.

Two primary sedimentation basins, each 29 × 76.5 × 9 ft. deep, having a total volume of 300,000 gal. are operated at the average rate of 132,000 gal. per hour for a 2.33-hr. retention.

TABLE 4.—Summary of 1944–45 Operating Data, Belleville, Ill.

Item	Average
Raw sewage flow (m.g.d.)	3.15
Per cent of B.O.D. removed	71.3
Flow given full treatment (m.g.d.)	2.23
Population equivalent of treated sewage	48,400
Settleable solids (ml. per liter):	
Raw sewage	0.2 to 18.0
Primary effluent	0.0 to 1.4
Final effluent	0.0 to trace
Air for aeration (cu. ft. per gal.)	1.1 to 7.8
Mixed liquor suspended solids (p.p.m.)	1,800 to 3,100
Sludge index	50 to 700
Return activated sludge suspended solids (p.p.m.)	3,700 to 7,800
Per cent return sludge to aerator flow	35 to 90
Primary sludge to digesters (gal. per day)	21,000 to 36,800
Primary sludge:	
Total solids (%)	3.3
Volatile solids (%)	69.0
Digester temperature (F.°)	93.5
pH:	
Digester contents	7.1
Raw sewage	6.6 to 8.4
Primary effluent	6.7 to 8.4
Final effluent	7.3 to 7.7
Cost of operation (dollars)	30,467.52
Cost per capita	1.02
Cost per m.g. treated	26.50
Cost per 1,000 lb. B.O.D. removed	10.53
Cost per population equivalent	0.63

Each of three aerators has a volume of 245,000 gal. and a capacity of 57,200 gal. of mixed liquor per hour for an aeration period of 4.3 hours at the 1944–1945 average flow rates.

The aerated mixed liquor is discharged to a common mixed liquor effluent channel from which it is discharged to two final sedimentation basins, operated in parallel. Each basin has a volume of 184,000 gal. and is operated at a capacity of 85,800 gal. per hour for a retention of 2.15 hours.

Two blowers, each having a capacity of 3,000 c.f.m., provide compressed air for the activated sludge process.

The two digesters have a volume of 337,000 gal. each and are interconnected so that they can be operated in parallel or series. Digester supernatant is discharged to the raw sewage wet well except when it is necessary to discharge it to a lagoon to prevent overloading of the plant.

Digested sludge is conditioned with lime and ferric chloride and filtered on an Oliver vacuum filter having a filter area of 134 sq. ft. This equipment is used only when sludge conditions are favorable to economical operation of the filter. When the filter is not operated the digested sludge is drawn to the lagoon, which was necessitated by the filter being 50 per cent under capacity when it is operated 5 days per week. The filtrate is discharged to the raw sewage wet well and the sludge filter cake is dumped in a nearby field for ageing.

Plant Capacity and Loading Data

According to the preliminary engineering reports of August, 1935, and September, 1937, this plant was designed on a basis of a population and a population equivalent load from industries of 40,000 people, which at that time was thought adequate for the city's needs to 1955. During construction, however, the plant's secondary capacity was reduced approximately one-fourth by the omission of one of the four aeration tanks, which leaves a theoretical plant capacity for approximately 33,000 people.

Since May, 1941, the load on the plant has exceeded the design capacity, which condition has grown steadily worse, making it impossible to operate in such a manner as to discharge into Richland Creek an effluent which will not cause objectionable odors or objectionable stream conditions. This load, in terms of population equivalent, has progressed from a 1941–1942 daily average of 42,000 to 59,500 in 1944–1945. Shock loads have been great enough to cause the population equivalent (calculated from the analyses of composite samples of raw sewage) to reach 182,000 people. These figures would indicate that the plant is about 30 per cent undersize. They do not, however, represent the true picture and are of no value in determining the needed operating capacity.

Sewage Gas Engine Savings

The sewage gas engine, which averages 20 hours per day in operation, saves the city approximately $300 per month in the purchase of electric power. The average cost of operation is about $600 per year for oil and repairs. This represents a saving of $3,000 per year.

Sludge Sold as Fertilizer

Sewage sludge cake resulting from the dewatering of digested sludge with the vacuum filter is available for sale as a soil conditioner or fertilizer at the charge of $0.75 per cu. yd. in truck lots. While this material is an excellent soil conditioner it can hardly be classed as a fertilizer.

TIPS AND QUIPS

Operators' Forums

Mingling peacefully among the crowd emerging from the final session of the 19th Annual Meeting at Toronto, we suddenly found ourselves engulfed in a flying wedge of New Jersey operators who had but a single thought. It was "Why could not more program time be given to the annual Operators' Forum?"

What finer compliment could have been paid to the forum they had just left, which had been so ably handled by H. S. Nicklin and Dr. A. E. Berry of the Canadian Institute? But then, the Institute's "guided discussions" have long been a highlight of its annual meetings, and the success of the 1946 international edition was assured by its experienced leadership.

It is not surprising that the Toronto forum appeared to be all too short, because there was, after all, a two-year accumulation of pent-up operators' shop talk to be released in the three-hour session. There is merit, however, in the question raised by the New Jersey enthusiasts, and they may rest assured that their suggestion is being considered by the Federation's Program Committee.

To Lime or Not to Lime

And now comes Schlenz and Buswell to explain (and prove) why the addition of lime to an ailing digester is malpractice ("Important Considerations in Sludge Digestion," this issue). According to these authorities, the reaction of lime with the organic acids produced in the intermediate stages of digestion resolves these acids into the acetate form, which is not readily decomposed by the bacteria into carbon dioxide and methane, the desired end products. The implication of this concept is that digester pH control by chemical applications is taboo; a conclusion which is logical when it is considered that pH variation is an effect and not a cause of unbalanced and unsettled digester operation.

Which takes us back about 15 years to an experience with a small digester that had been on a foaming rampage continuously for several weeks, in spite of the operator's religious daily addition of 100 lb. of lime. Assigned to help clear up the trouble, we noted that the pH was quite low, and concluded that it should be raised at all costs. Forthwith, enough milk of lime was poured into the digester to whitewash Tom Sawyer's fence and the entire west bank of the Mississippi River from Hannibal to New Orleans. Visions of finding everything serene on the next morning were sadly shattered when it was observed not only that the foaming continued unabated, but that pH had not changed enough to measure with our field kit!

Now, at last, do we have scientific justification for our loss of faith at that time in liming as a remedy for upset digesters.

Phacts by Phair

The Federation Luncheon address given at the Toronto meeting by Dr. J. T. Phair was one of the hits of the conference. Dr. Phair, who is Ontario's Deputy Minister of Health, enumerated frankly and forthrightly his views on the work of the sanitary engineer in the betterment of environmental sanitation. As an interested observer not directly engaged in the field, he offered both praise and constructive criticism.

His reference to "the penny-pinching taxpayer who wants primary (sewage) treatment now and complete treatment when he has exchanged his tin horn for a harp" evoked many understanding recollections of such contacts. We also liked Dr. Phair's admonition, when deploring the lack of public relations activity, that "It is better to appeal to the emotions of the housewife rather than to logic, in the promotion of sanitation works."

The quip that concluded Dr. Phair's remarks was a definition—"Conventions are the best excuse for the organized release of inhibitions." A good time was had by all!

Just Like a Rattlesnake

Alert to the explosion hazards at an isolated digester control building, the management of the Fort Wayne, Ind., sewage treatment plant has taken precautions to insure that operating personnel will be warned if conditions become dangerous.

According to Chemist Paul Bruner, an ingenious member of the operating staff has rigged up an alarm system by which a signal is given at the plant administration building when a combustible gas indicator in the remotely located control room registers the onset of an explosive atmosphere. A buzzer sounds a characteristic note to attract the attention of the operator on duty, and warns him that a prompt but cautious investigation is in order.

Corrosion in Gas Scrubbers

Another tip heard at the 1946 meeting of the Central States Sewage Works Assn. will interest operators who are troubled by corrosion of the interior of digester gas purifier boxes used for removing excessive concentrations of hydrogen sulfide. The suggestion was made by Chemist L. W. Hunt of the Galesburg (Ill.) Sanitary District.

Chemist Hunt has had negligible success with paints applied to the inside of the metal boxes containing the iron "sponge," through which the gas is passed for removal of the H_2S. Severe pitting resulted until he lined the boxes with 15-lb. asphalt roofing paper, fitted carefully to cover all of the exposed metal surface. Although the paper lining must be renewed periodically, the method is deemed to be a good practical solution of the problem at Galesburg.

It is possible that the success of this procedure is in part due to the insulating value of the paper, which results in a minimum of moisture condensation within the scrubbers.

Los Angeles City Limits

Like Ponce De Leon planting the banner of Spain on the Florida shore, so did R. F. Brown of Los Angeles serve notice of California's welcome to the Federation in 1947, when he placed a large sign containing the words in the above caption upon the speaker's table at one of the Toronto sessions.

Mr. Brown also brought to Toronto the greetings of the Los Angeles Department of Public Works and of the Sanitary Engineering Division of the Los Angeles Section, ASCE. A letter from H. P. Cortelyou, Engineer-Director of the city Bureau of Maintenance and Sanitation, urged Federation members to visit Los Angeles en route to or from San Francisco next July, and to inspect sewage works developments in that area. These sentiments were echoed by James M. Montgomery, chairman of the local ASCE group, who stated that inspection trips would be arranged and transportation furnished for those giving advance notice.

The door to California has a long latchstring!

Don't Be a "Cut-Off"

Several hundred good readers of THIS JOURNAL will have their names removed from the mailing list after they receive this issue, just because they will have been a bit tardy about remitting 1947 dues. Nearly all of them will be reinstated before the year is over, to be sure, but there are several sound reasons why they should maintain their memberships without interruption, to wit:

1. Supplies of some back numbers may be exhausted before they are reinstated, so that a complete file for the year cannot be furnished.

2. Complimentary copies of any new manuals of practice go only to *current members at the time of issue;* those whose names are not on the mailing list at the time of issue must purchase their copies.

3. Extra work is required by the Member Association secretary, by Federation headquarters and by the mailing list clerks at the printing plant, with a chance for errors to be made at each place.

There is still time to avoid being a "cut-off." Just dig out that last dues notice from the secretary of your association, pin a check to it and send it in immediately. If you cannot find the notice, send in the check anyway—without further delay!

Editorials

1947 CONSTRUCTION PROSPECTS

The $2,000,000,000 question of the moment is: "What are the prospects for sewage works construction in 1947?" This is no attempt to arrive at an answer, for no crystal ball could integrate the conglomerate of variables involved into any prediction beyond one that the record of 1947 could not possibly be worse than that in 1946. But the question still affords plenty of vitamins for thought and conversation.

The year 1946 left housewives waiting for washing machines, veterans waiting for housing, cities waiting for needed public works, and our national economy waiting for some semblance of stability—all while labor, management and government were preoccupied with knocking chips from each other's shoulders. A favorable sign at the end of the year was the resistance of government to the demands of some irresponsible and unreasonable labor leaders. The plowing under of more and more government controls removes other shackles that have hampered reconversion in the construction industry.

Two factors: first, the shortages of most construction materials and, second, pyramiding costs which invalidated engineer's estimates and financing plans, were responsible for the limited volume of public works construction in 1946. The summer of 1947 may well bring the peak of residential construction; even so, the production of building materials is approaching such a rate that a fair volume of heavy construction might be supplied. With reasonable stability in wages (by no means assured), and with government control limited strictly to non-essential construction, the wishful thinker will visualize an upturn in public works building in 1947, including a substantial number of sewage works projects. The most hopeful optimist, however, will not picture such construction keeping apace of the continued planning of sewers and treatment plants during the year, and the already sizable planned backlog of sewage works construction will undoubtedly assume even greater proportions.

A great many municipal authorities are reluctant to take bids on planned improvements that are badly needed at this time, because of presently inflated costs. Some of these officials may still be thinking in terms of prewar prices, in the belief that there may be a recession to these levels before too long. A glance at the record of construction cost levels before and after World War I will prove that this viewpoint is decidedly unrealistic. Building prices in 1940 are now little more than interesting historical data.

But there is one favorable factor in the present scheme of things—the low prevailing rates of interest on municipal borrowing. Twenty years ago good municipal bonds carried 4 per cent interest; today the same bonds will find willing buyers at 1.5 per cent or less. Applied to serial bonds of 20-year term, the carrying charges on the 1.5 per cent securities would be 21 per cent less than they would aggregate on 4 per cent bonds. Present construction costs are approximately 40 per cent above the 1926 level, which advance is just about halved by the substantial saving in debt service.

While it is not unlikely that construction costs will decline from present peaks when supply and demand of materials approach equality and when labor improves in productiveness, it is also to be expected that the future will bring some increase in interest rates on municipal bonds. Evaluation of these countercurrent reactions may yield the conclusion that little will be gained by further delay in carrying out work for which there is immediate need.

Though they may be reconciled to the higher costs, municipal officials must also be prepared to exercise patience and determination in the taking of bids. This procedure nowadays is a sort of trial and error or "try-on-for-size" process, in that two or more lettings may have to be arranged before an acceptable contract is forthcoming. Even so, it is to be hoped that local governments will press to undertake such sewage works improvements *as are badly needed,* rather than to defer to certain privately enterprised building of doubtful public necessity. There is justification, as an inflation curb, for continued governmental restriction of this latter type of construction.

FEDERAL POLLUTION CONTROL LEGISLATION ACTIVITY

Among the many important matters awaiting action by the 80th Congress there is certain to be at least one bill pertaining to Federal stream pollution legislation. Considerable activity at the end of 1946 was directed toward the development of a bill that might receive support from all of the interests concerned with the problem.

On October 21, the Council of State Governments invited representatives of interested organizations to a conference in Washington for the purpose of bringing together some of the divergent viewpoints. Although this conference was extended into an extra day, but little tangible progress was made. The opportunity for exchange and discussion of variant opinions was undoubtedly beneficial, however.

At its annual meeting at Cleveland on November 11, the Conference of State Sanitary Engineers directed its Committee on National Water Policy to draft Federal water pollution control legislation to be recommended for filing in the 80th Congress by the Association of State and Territorial Health officers. Under the leadership of Arthur D. Weston, another conference of interested agency representatives was held in New York on November 22, 1946. From this conference came a recommendation that an amended version of H.R. 4070 (introduced by Congressman Spence in the 79th Congress) be supported.

The proposed modification of H.R. 4070 includes a reinforced enforcement clause that may still be objectionable in some quarters. If the elements that have previously favored the Mundt type of legislation will concede to this bill, however, it is believed that supporters of the original Spence bill should likewise concede to it. It is evident that both groups will have to make some concessions if it is hoped to bring about enactment of some form of Federal legislation.

W. H. W.

Proceedings of Member Associations

CALIFORNIA SEWAGE WORKS ASSOCIATION

18th Annual Meeting

Monterey, Calif., June 9–11, 1946

Convening for the first time in two years the California Sewage Works Association had the largest registered attendance in its history with 191 delegates present at the 18th annual convention, held at Monterey on June 9–11, 1946. The growing problem of disposal of industrial wastes facing governmental agencies and industry was emphasized.

The Get-To-Gether Smoker in the Solarium of the Hotel San Carlos was well attended. The sound film "Clean Waters," portraying the fundamentals of water purification and sewage treatment, was the highlight of the occasion.

Benn Martin, Assistant Superintendant of the San Francisco Richmond Sunset treatment plant, presided at the chemists' breakfast. Fifty members were present to enter into the discussion on the techniques in use in various plant laboratories for determining suspended solids in sewage. The majority of those at the breakfast favored the *Standard Methods* Gooch crucible-asbestos fibre mat method. This indicated a trend away from the Chicago Sanitary District method, a technique which employs Whatman No. 1 filter paper in conjunction with a Büchner funnel. At the last Chemists' Breakfast a show of hands indicated that the two methods were in equal use.

At the day's technical session the first paper was presented by Richard Pomeroy, of Montgomery and Pomeroy, Pasadena, and was entitled "Progress Report on Sulfide Control Research." Reuben F. Brown, Superintendent of Sewer Maintenance, City of Los Angeles, followed with his paper on "Experimental Work on the Elimination of Hydrogen Sulfide in the Los Angeles Sewerage System." John S. Longwell, Chief Engineer and General Manager of the East Bay Municipal Utility District, spoke on "Sewage Disposal for Special District No. 1 of the East Bay Municipal Utility District," and a joint paper by Harvey House, of the Pacific Coast Clay Products Institute, and Richard Pomeroy on "Sewer Pipe Jointing Research" ended the morning session.

The afternoon session resumed with an explanation of the new Construction and Employment Act by H. H. Jaqueth, Administrator, State Department of Finance. J. J. Pederson's paper "Observations of Sewage Plant Operation at Army Installations," based on his experience as Sanitary Engineer with the 9th Service Command, was discussed by several members from the floor. James H. Van Norman, Chief Operator of the Los Angeles Hyperion plant, discussed the "Control of Odors and Flies by the Use of Chemicals," and to conclude the day's program, Arthur Reinhardt of the State Department of Public Health gave an illustrated talk on "Chlorination Studies of Los Angeles Sewage."

Mr. Frank M. Stead, Chief of the Division of Environmental Sanitation of the State Department of Public Health, speaking at the Annual Banquet, stressed the importance of making industry a party to the solving of industrial waste problems in any regulatory program.

Following Mr. Stead's talk, the following officers were elected to serve during 1946–47:

President: G. A. Parkes, Los Angeles.
Vice-President: H. L. May, Palo Alto.
Second Vice-President: Ray L. Derby, Los Angeles.
Secretary-Treasurer: Arthur G. Pickett, Los Angeles.
FSWA Director: Blair I. Burnson, Oakland.

Marvin Anaya of the San Francisco City Engineer's Office presided at the Operators' Breakfast and Round Table held in the Casa Munras Hotel on the second morning. Mr. Anaya proposed for discussion the question "How are Screenings Handled at your Plant?" Each member in turn was requested to stand and answer this question for the benefit of the group.

President Fraschina called the session to order at 9:30 and turned the meeting over to Mr. Anaya, Chairman for the day. Blair I. Burnson's paper on the "Effect of Garbage Grinders on the Design of Sewage Treatment Plants" opened the program and was followed by a discussion prepared by A. M. Rawn and presented by Homer W. Jorgensen.

Carl Hoskinson, Chief Engineer of the Department of Water and Sewers, Sacramento, and F. S. Miller of Palo Alto explained the operation of sewer rental ordinances in their respective cities. Mr. Arthur G. Pickett, Deputy Los Angeles County Engineer, concluded the session with a paper entitled "Protection of Underground Waters from Sewage and Industrial Waste."

Following the luncheon, President Fraschina called the business meeting to order. Reuben Brown, Chairman of Membership, reported the membership to be the largest in history with a total of 307, of whom 35 are new members. Carl Hoskinson suggested that the State Department of Public Health be requested to take over the certification of operators on a legal basis, and this action was formally taken by the Association.

A. G. Pickett,
Secretary-Treasurer

MISSOURI WATER AND SEWERAGE CONFERENCE

22nd Annual Meeting

Columbia, Mo., October 21–22, 1946

The 22nd Annual Meeting of the Missouri Water and Sewerage Conference, held October 21–22 in Columbia, Mo., was an outstanding success, with 183 members and guests registered for both sections. Papers pertaining to sewage works topics presented at the meeting were:

"Sewer Construction Practice," by Chester Y. Hogue, Clay Products Association of Chicago.

"Design Problems of Small Sewage Treatment Plants," by A. J. Pfeiler, Edward A. Fulton, Engineers, Clayton, Mo.

"Maintenance and Operation of Motors and Controls in Pumping Stations and Sewage Plants," by J. C. Bibbs of the Westinghouse Electric Company of St. Louis, Mo.

"Package Sewage Plants," by R. C. Gloppen of the Yeomans Brothers Company of Chicago.

"Location of Lost Underground Sewers," by D. L. Blaik, Water Leak Detector, Columbus, Ohio.

"Sanitation Difficulties in Small Real Estate Developments," by Fred Barnes, Engineer, Gast Real Estate and Development Co., Kirkwood, Mo.

The following officers were elected to serve during the ensuing year:

Chairman: Melvin P. Hatcher, Kansas City.
Vice-Chairman: Rogers C. Higgins, Hannibal.
Secretary: Warren A. Kramer, Jefferson City.
FSWA Director: W. Q. Kehr, Jefferson City.

Mr. Kehr will fulfill the unexpired term of Geo. S. Russell, who was recently elected as the Vice-President of the Federation. The current term of the Missouri Director will end in October, 1948.

WARREN A. KRAMER,
Secretary

NORTH DAKOTA WATER AND SEWAGE WORKS CONFERENCE

18th Annual Meeting

Mandan, North Dakota, September 26–27, 1946

The Eighteenth Annual Meeting of the North Dakota Water and Sewage Works Conference was called to order by President Svenkeson on September 26 in the War Memorial Building at Mandan, North Dakota. A total of 97 members and guests registered.

The program included three papers of specific interest to sewage works technicians, as follows: "Missouri River Development Program," by Col. W. W. Wanamaker, Corps of Engineers; "What a Sewage Works Operator Should Know and How to Obtain the Information," by Prof. G. J. Schroepfer of the University of Minnesota; and "Pump Maintenance and Performance—A Panel Discussion," led by John B. Kleven. Other papers were primarily of interest to water works personnel.

Since the North Dakota Water and Sewage Works Conference is fundamentally concerned with sanitation problems and because it is believed that further emphasis should be given the collection and disposal of garbage and refuse in the cities of North Dakota, it was resolved that the Conference go on record as endorsing a study of garbage collection and disposal methods and costs pertaining thereto. President Svenkeson appointed the following committee of five to make the study and report at the next meeting: A. L. Bavone, Chairman, John Kleven, Everett Lobb, E. J. Booth and J. H. Svore.

Action was also taken at the business meeting to appropriate $25 annually toward the expenses of the Dakota Conference Director to the annual convention of the Federation of Sewage Works Associations.

Officers elected to serve during 1946–1947 were:

President: John B. Kleven, Grand Forks.
Vice-President: Harley G. Quam, Lisbon.
Secretary-Treasurer: J. H. Svore, Bismarck.

J. H. SVORE,
Secretary-Treasurer

PENNSYLVANIA SEWAGE WORKS ASSOCIATION

20th Annual Meeting

State College, Pennsylvania, August 28–30, 1946

The Twentieth Annual Meeting of the Pennsylvania Sewage Works Association was held concurrently with the Pennsylvania Water Works Operator's Association at State College on August 28–30, 1946. A total of 197 members and guests were registered.

An outstanding program of technical

papers was presented on the opening day. Included were the following:

"Pennsylvania's Program for Stream Pollution," by H. E. Moses, Chief Engineer of the Pennsylvania Department of Health at Harrisburg.

"Financing Sewage Treatment Works," by Dr. H. F. Alderfer, Director of the Bureau of Municipal Affairs at Harrisburg, and discussed by C. W. Tillinghast, Director of the Southeastern Division of the Pennsylvania Economy League, Inc.

"Federal Aid in the Advance Planning of Public Works," by Wm. J. Finley, Pennsylvania Representative of the Federal Works Agency.

"Operation of Army Sewage Plants," by Rolf Eliassen, formerly Lt. Col. in the Corps of Engineers, U. S. Army, now Professor of Sanitary Engineering at New York University. The Eliassen paper was discussed by Col. W. A. Hardenberg, *Public Works Magazine*, New York City.

"Ground Garbage—Its Effect Upon the Sewerage System and the Treatment Plant," by S. L. Tolman of the Jeffrey Manufacturing Company, Columbus, Ohio; discussed by Ben. H. Barton, Chief Operator of the Findlay, Ohio, sewage treatment plant.

A Sewage Works Operator's Clinic was held with L. D. Matter, District Engineer of the Pennsylvania Department of Health, presiding. R. W. Simpson, Sanitary Engineer of Gilbert Associates, Inc., presented informative discussions on plant operation procedures and on the use of DDT in sewage treatment plants.

At the annual dinner, H. E. Moses presided as toastmaster and Senator Joseph A. Esquirol of Southhold, L. I., gave an interesting and informative address. Francis S. Friel, Vice-President, FSWA, was the official representative of the Federation at the Conference and discussed the aims and progress of the Federation. "Clean Waters," the new anti-stream pollution technicolor moving picture, was shown by the General Electric Company to the 170 in attendance at the banquet.

The August 30 session included:

"Present Status of Industrial Waste Treatment," by A. L. Fales of Metcalf and Eddy, Boston, Mass., with a discussion by C. L. Siebert, Consulting Engineer, Camp Hill, Pa.

"B.O.D. Determination as Applied to Industrial Wastes," by R. F. Weston of the Atlantic Refining Company of Philadelphia, with a discussion by Gladys Swope, chemist, Allegheny County Sanitary Authority of Pittsburgh.

"Trickling Filter Performance," by Dr. H. A. Thomas, Jr., of Harvard University, with discussion by R. S. Rankin of The Dorr Company, New York City.

At the business meeting favorable action was taken to amend the constitution of the PSWA with regard to dues and terms and duties of officers, thus conforming with the constitution and by-laws of the Federation of Sewage Works Associations.

Professor Raymond O'Donnell was unanimously elected as an Honorary life member of the PSWA.

One of the highlights of the conference was the introduction of the Lectures and Laboratory Guide publications, prepared by the PSWA and based on the 1945 Short Course for Sewage Works Operators.

The following officers were elected for the coming year:

President: William J. Murdoch, Pittsburg.

1st Vice-President: Norman G. Young, Phoenixville.

2nd Vice-President: Charles H. Young, Meadville.

Secretary-Treasurer: Bernard S. Bush, Wilkes-Barre.

FSWA Director: L. D. Matter, Harrisburg.

BERNARD S. BUSH,
Secretary-Treasurer

MEMBER ASSOCIATION MEETINGS

Association	*Place*	*Time*
New York State Sewage Works Assn.	Henry Hudson Hotel, New York City, N. Y.	Jan. 17
Texas Sewage Works Section	A. and M. College, College Station, Texas	Feb. 10–13
New Jersey Sewage Works Assn.	Stacy-Trent Hotel, Trenton, N. J.	Mar. 19–21
Arkansas Water and Sewage Conf.	Engineering Auditorium, Fayetteville, Ark.	Apr. 14–16
Montana Sewage Works Assn.	Harve, Montana	Apr. 23–24
Federation of Sewage Works Assns.	**San Francisco, Calif.**	**July 22–24**
Pennsylvania Sewage Works Assn.	Electrical Engineering Bldg., State College, Pa.	August
North Dakota Water and Sewage Works Conf.	Dacatoh Hotel, Grand Forks, N. D.	September
Ohio Conference on Sewage Treatment	Deshler-Wallick Hotel, Columbus, Ohio	Oct. 2–3
Missouri Water and Sewage Conf.	Jefferson City	October

Twentieth Annual Meeting

FEDERATION OF SEWAGE WORKS ASSOCIATIONS

San Francisco — July 22–24

in conjunction with

CALIFORNIA SEWAGE WORKS ASSOCIATION

Federation Affairs

MINUTES OF MEETING OF 1946 BOARD OF CONTROL

October 6, 1946

The Annual Meeting of the 1946 Board of Control of the Federation of Sewage Works Associations was called to order by President J. K. Hoskins in the Royal York Hotel, Toronto, Canada, at 10:20 A.M., October 6, 1946.

Roll call was as follows:

PRESENT IN PERSON

Member Association or Office Represented	*Representative*
President	J. K. Hoskins
Vice-President	F. S. Friel
Past President	A. E. Berry
California Sewage Works Association	C. C. Kennedy
Central States Sewage Works Association	C. A. Larson
Dakota Water and Sewage Works Conference	K. C. Lauster
Federal Sewage Research Association	M. Le Bosquet, Jr.
Florida Sewage Works Association	David B. Lee
Georgia Water and Sewage Association	H. A. Wyckoff
Iowa Sewage Works Association	John W. Pray
Maryland-Delaware Water and Sewerage Association	R. E. Fuhrman
Michigan Sewage Works Association	W. F. Shephard
Missouri Water and Sewerage Conference	G. S. Russell
New England Sewage Works Association	L. W. Van Kleeck
New Jersey Sewage Works Association	P. N. Daniels
New York Sewage Works Association	E. J. Smith
Ohio Sewage Works Conference	A. H. Niles
Pennsylvania Sewage Works Association	F. S. Friel
Texas Sewage Works Association	E. J. M. Berg
Director-at-Large	F. W. Mohlman
Director-at-Large	C. A. Emerson
Director-at-Large	H. F. Gray
Water and Sewage Works Manufacturers Association	L. H. Enslow
Water and Sewage Works Manufacturers Association	F. W. Lovett
Publications Committee	F. W. Gilcreas
Sewage Works Practice Committee	M. M. Cohn
Research Committee	W. Rudolfs

PRESENT IN PERSON, ACTING BY PROXY

Member Association or Office Represented	*Representative*
Treasurer	W. J. Orchard (for W. W. Deberard)
Arizona Sewage and Water Works Association	A. L. Frick, Jr. (for G. W. Marx)
Water and Sewage Works Manufacturers Association	A. E. Paxton (for Linden Stuart)

Of the 41 members of the Board of Control, 27 were present in person and three were represented by proxy, constituting a quorum. Executive Secretary-Editor Wisely was also in attendance.

President Hoskins opened the meeting with the following remarks:

"Regardless of the many restrictions occasioned by war activities the Federation has enjoyed a vigorous growth in its functions, its membership and its financial status. Now that such restrictions are removed, we are able to resume our annual meetings and devote our attention more fully to committee activities, expansion of Federation membership, stimulation of member organizations, production of sanitation manuals and improvements in our JOURNAL.

"The reports of our various committees will present in detail the progress made in these fields during the past year. Our membership has increased from 3,216 to 3,550. Owing to the continuing efforts of our Secretary and Organization Committee, two new regional associations have completed requirements for affiliation with the Federation and negotiations to this end are progressing with four additional organizations, either existing or in process of formation.

"Our financial status continues to be satisfactory and we have considered it advisable to invest an additional $5,000 of our surplus funds during the year.

"Our technical committees have made definite progress in their assigned duties and their members have devoted many hours of hard work toward the preparation of material for additional manuals, which are a most important contribution to the Federation's activities.

"The spirit and morale of the organization have continued at a high level. The cooperation of the committee chairmen, the officers, the members of the Board of Control and especially the uniformly high grade of service rendered by our Secretary and his staff have contributed to this favorable situation.

"It is a high privilege and honor to have served as your President and I thank you all most sincerely for your fine support and interest. I can only ask that my successor be afforded the same loyal cooperation."

The minutes of the Eighteenth Annual Meeting of the Board, held at Chicago on October 17–18, 1945, were approved as published in SEWAGE WORKS JOURNAL, 18, 1, 131 (Jan., 1946).

The Executive Secretary-Editor presented his report for the year ended September 30, 1946, emphasizing the activity in Member Association organization, the increase in membership and the impetus in committee functions resulting from the end of the war. Attention of the Board was directed to the overages in the 1946 budget in regard to printing and mailing of publications and in travel expense. A seven per cent increase in printing and paper costs, acceptance of the NRC report for publication in the September, 1946, issue and unanticipated costs of the new Manual of Practice No. 2 were responsible for the overage in the former item. The travel expense budget was exceeded because of the Secretary's effort to "complete the circuit" of all North American Member Association meetings in 1946.

In moving acceptance of the report, Mr. Emerson proposed (1) that no budget items be exceeded in the future without authorization of the Finance Advisory and Executive Committees and (2) that each member of the Board be furnished a copy of the "Secretary's Manual" as prepared by the Executive Secretary for the guidance of Member Association secretaries. The motion was seconded by Mr. Orchard and carried.

President Hoskins referred the matter of the 1946 budget overages to the Finance Advisory Committee for study and report.

The Executive Secretary presented a special report on his investigation of the availability and costs of ring binders suitable for filing manuals of practice as issued, which study was requested by the 1945 Board. Samples of various binders were displayed and there was unanimous approval of the type exemplified by the No. BLS–3164 binder manufactured by the Barrett Bindery Company of Detroit, Michigan. By motion, seconded and carried, authorization to purchase such binders for resale to those desiring them was given to the Publications Committee.

In the absence of Treasurer DeBerard, his report for the year ended September 30, 1946, was presented by the Executive Secretary. The unencumbered total balance in banks at the end of the year was $17,978.14, distributed as follows:

First National (Champaign)	$ 7,978.14
Busey's State (Urbana)	5,000.00
Continental-Illinois (Chicago) ...	5,000.00
Total	$17,978.14

The report also showed that an additional $5,006.53 was invested in U. S. Treasury Notes (7/8%) during 1946, in accordance with instructions of the Finance Advisory Committee, bringing the total of invested funds to $19,733.78. By motion, seconded and carried, the report was received subject to the annual audit and the Finance Advisory Committee was empowered to select auditors to make the fiscal year audit on December 31, 1946.

Chairman Gilcreas presented the report of the Publications Committee, which offered recommendations concerning (1) the proposed publication of SEWAGE WORKS JOURNAL on a monthly schedule, (2) the employment of an assistant to the Executive Secretary-Editor and (3) the production of a 20-year index of the JOURNAL. After discussion, these recommendations were referred back to Chairman Gilcreas for further study and report later in the session.

The report of the Executive Committee was presented by President Hoskins. Recommendations were offered pertaining to (1) monthly publication of the JOURNAL, (2) employment of an assistant to the Executive Secretary-Editor, (3) revision of the advertising rate schedule for the JOURNAL and (4) the 1947 budget. By motion, duly seconded and carried, the report was tabled for further investigation and later consideration.

Having completed his supplementary study of the Publications Committee report, Chairman Gilcreas requested that this matter be taken from the table for action. The following recommendations were adopted, by motion, seconded and carried:

1. That SEWAGE WORKS JOURNAL be continued as a bimonthly publication in 1947 and that decision as to increasing the publication frequency to a monthly basis be deferred until it is apparent that adequate technical material of the present established standard of quality is available to insure as a monthly the continued value of the JOURNAL.

2. That provision be made beginning with the 1947 budget for a properly qualified assistant to the Executive Secretary-Editor.

3. That a cumulative index be prepared to cover the first twenty volumes of the JOURNAL, to be published in the same format as the first (Nine-Year) index, and to include the titles of abstracted articles; further that future cumulative indexes be produced at 10-year intervals.

Mr. Enslow suggested that the annual membership directory as published in the March issue of the JOURNAL might be enhanced by the addition of a supplementary section listing members according to the cities in which they reside. The matter was referred to the Publications Committee for report at the Twentieth Annual Meeting.

Finance Advisory Committee Chairman Orchard reported on the committee's investigation of the overages in printing and travel expense in the 1946 budget. By motion, seconded and carried, all past expenditures in excess of the 1946 budget were approved and Mr. Orchard was directed to draft an amended 1946 budget for consideration by the 1947 Board.

The Executive Committee report was taken from the table and the following recommendations were adopted by motion, seconded and carried:

1. That SEWAGE WORKS JOURNAL be continued as a bimonthly publication during 1947 but that plans be made to initiate a monthly publication schedule with the issue of January, 1948, provided that the volume of material is sufficient by that time, in the opinions of the Editor and Advisory Editor, to justify the change.

2. That the Executive Secretary-Editor be authorized to employ, with the approval of the Executive Committee, a qualified assistant at a starting salary not to exceed $4,000 per annum, to begin on or about January 1, 1947.

The further recommendations of the Executive Committee regarding advertising rates and the 1947 budget were left in the hands of the Finance Advisory Committee for report to the 1947 Board of Control on October 9, 1946.

Chairman Berry presented the report of the General Policy Committee, including the following recommendations:

1. That consideration be given the annual appointment of a Nominating Committee to canvass the field of candidates and to offer nominations of Federation officers to the Election Committee.

2. That a Quarter Century Operators Club Committee be created to consist of members of the club, such committee to be responsible for the processing of applications, the maintenance of a membership roll including related biographical data, and the arrangement for participation of members of the club in functions conducted at annual meetings of the Federation.

3. That the Federation furnish a suitable membership certificate to each member of the Quarter Century Operators Club.

4. That an aggressive policy be maintained at all times in regard to the organization of new Member Associations of the Federation.

These recommendations were adopted by motion, duly seconded and carried.

It was further moved, seconded and carried that the Nominating Committee approved above be comprised of the last five living Past Presidents of the Federation, with the senior Past President serving as chairman. Directors Larson and Niles dissented in the vote on this motion.

Chairman Cohn presented the report of the Sewage Works Practice Committee, in which was reviewed the status of seven manuals of practice in preparation and the plans of the Committee in regard to the production of other manuals. The report was accepted, by motion, seconded and carried.

In the discussion on the manual of practice program, Mr. Orchard moved that the cost of future manuals be charged against surplus and that such expenditures be permitted only by authorization of the Executive Committee upon recommendation of the Finance Advisory Committee. The motion was seconded and carried.

In his report for the Research Committee, Chairman Rudolfs reviewed the recent trends in research as reflected by the literature during the war period of 1941–45. It was shown that research on sewage filtration and sludge digestion is declining in spite of the high level of interest in these two methods of waste treatment, and that the volume of literature on stream pollution and industrial wastes has held reasonably steady while there is a decrease in the published works on sewage research as a whole. There were no recommendations.

President Hoskins called attention to the funds now available through the National Institute of Health for the financing of all phases of sanitary engineering research in approved institutions. A special Study Committee has now been created in the Institute to stimulate research projects and to review applications for funds. Dr. Rudolfs suggested that the Federation might seek an allocation of such funds to finance a 5 or 10 year review of sewage and industrial wastes research for the purposes of evaluating the work completed and underway and of determining the nature of research for which the need is greatest. It was moved, seconded and carried that a special committee comprising the chairman of the Research Committee with one other person appointed by the President be authorized to investigate the eligibility of the Federation as an applicant for the funds available through the National Institute of Health.

The report of the Standard Methods Committee, presented by Chairman Hatfield, stated that the Ninth Edition of *Standard Methods* was scheduled to go to press in December, 1946. There were no recommendations and the report was accepted to be placed on file.

Mr. Emerson represented Chairman Velz in offering the report of the Nomenclature Committee, in which progress was cited in the production of the Glossary of Water and Sewage Control Engineering as jointly undertaken by ASCE, AWWA, APHA and the Federation. Difficulty has arisen in securing sufficient paper for the glossary and the publication date is highly uncertain. There were no recommendations. The Executive Secretary-Editor supplemented the report with an inquiry as to whether the Board desired the glossary to be published as a special bulletin in the 6 in. by 9 in. trim size in which it is to be produced for the other participating organizations or if it was preferred that the Federation's copies be produced as a manual of practice in the covers and in the 6¾ in. by 10 in. trim size which are standard for such manuals. It was pointed out that the 6¾ in. by 10 in. trim size would increase the cost of the Federation's copies by about $300. It was moved, seconded and carried that the Executive Secretary secure such advice as may be necessary from the Sewage Works Practice, Publications and Nomenclature Committees and proceed thereupon to arrange for production of the Federation's copies of the glossary as a standard manual of practice in the 6¾ in. by 10 in. trim size.

The report of the Committee on Operation Reports was presented by the Executive Secretary. By motion, seconded and carried, the following recommendations were approved:

1. That the 1946 *William D. Hatfield Award* be made to Walter M. Kunsch for his report on the operations of the Urbana-Champaign (Ill.). Sanitary District for the year ended April 30, 1945.

2. That beginning in 1947, the *William D. Hatfield Award* be made to recognize three operation reports each year, such reports to represent those judged to be the best submitted in accordance with prevailing rules (*a*) for plants serving populations of less than 10,000, (*b*) for plants serving populations of 10,000 to 100,000 and (*c*) for plants serving populations greater than 100,000. It is further recommended that the three certificates tendered in token of the award shall be identical, except that each shall indicate thereon the population grouping which includes the plant reported.

3. That no attempt be made to classify operation report awards in accordance with the type of plant.

4. That the rules be made clear to the effect that the period of time covered by competing reports is a year of operation next preceding the June 30 deadline for the receipt of reports by the Federation Secretary.

5. That the present method of rating reports be continued.

6. That the NYSSWA be invited to submit the detailed recommendations on rating procedure to which reference is made in the letter addressed to the Secretary of the Federation under date of May 28, 1946.

The activities of the Industrial Wastes Committee were summarized in the report presented by Chairman Mohlman. Reference was made to plans of the committee for its members to contribute special industrial waste articles for the JOURNAL, such contributions "to be of a type to create a continuing interest in this field, and designed to make the JOURNAL the most authoritative source of information on the disposal of industrial wastes." There were no recommendations and acceptance of the report was moved, seconded and carried.

The Committee on Qualifications of Operators was represented by Chairman Van Kleeck. There was no report, this Committee having been continued only to activate the provisions of its 1945 report.

Mr. Emerson reported for the Committee on Water and Sewage Development (jointly representing AWWA, WSWMA, NEWWA and the Federation), recommending that the Board reaffirm its belief in the importance of water and sewage works projects in the postwar world and in the continuation of activity of the joint committee if future developments demonstrate the need therefor. The recommendation was adopted, by motion, seconded and carried.

Chairman Emerson presented the report of the Committee on Honorary Membership, in which William John Orchard was nominated for membership in the grade of Honorary Member in recognition of his 16 years of faithful service on the Board of Control and his sound guidance of financial affairs of the Federation as chairman of the former Finance Committee and the present Finance Advisory Committee. The election of Mr. Orchard as the ninth Honorary Member of the Federation was unanimously approved, with instructions to the Editor to publish the Committee's citation in SEWAGE WORKS JOURNAL.

As presented by Chairman Fuhrman, the report of the Legislative Analysis Committee reviewed the progress of federal pollution control legislation in the 79th Congress and offered a recommendation "that the Federation support the Mansfield Bill or a measure similar thereto when such a bill is reintroduced in the 80th Congress." A motion was made, seconded and carried that the report be accepted with the deletion of the recommendation expressing approval of the Mansfield Bill, designated HR 6024 in the 79th Congress.

Mr. Van Kleeck read a resolution adopted by the New England Sewage Works Association and the New England Water Works Association, in which the Spence Bill considered by the 79th Congress was held to be more desirable than the compromise Mansfield Bill. It was then moved, seconded and carried that a special committee comprising Messrs. Fuhrman, Berry and Hoskins be instructed to draft a statement of Federation policy on stream pollution control legislation and to report at the meeting of the 1947 Board on October 9, 1946.

The report of the Awards Committee contained the following nominations for the 1946 awards of the Federation:

Award	*Recipient*
Harrison Prescott Eddy (Research)	H. Heukelekian
George Bradley Gascoigne (Operation)	LeRoy Winfield Van Kleeck
Charles Alvin Emerson (Federation Service)	F. Wellington Gilcreas
Kenneth Allen (Member Association Service):	
Central States Sewage Works Association	George Martin
Federal Sewage Research Association	Frank E. DeMartini
Iowa Sewage Works Association	Theodore R. Lovell
Michigan Sewage Works Association	Thomas J. Doyle
New Jersey Sewage Works Association	John R. Downes
North Carolina Sewage Works Association	Harold Benedict Gotaas
Pacific Northwest Sewage Works Association	William P. Hughes
Texas Sewage Works Section	E. J. M. Berg
Institute of Sewage Purification	John Henry Garner

All of the above nominations were unanimously approved, by motion, seconded and carried.

A general suggestion by the Awards Committee that the tokens emblematic of the Eddy, Gascoigne and Emerson awards should be in the form of permanent medals was referred back to the Committee for more detailed recommendations.

The report of the Organization Committee cited the increase in interest in the organization of new Member Associations since the end of the war, and referred to the "suggested form" of constitution and by-laws that has been approved for the use of the Executive Secretary in his Member Association development activities. The following actions were reported and/or recommended:

1. The Iowa Sewage Works Association was reorganized on August 23, 1945, by adoption of the constitution and by-laws approved by the Board of Control on October 17, 1945.

2. Board approval was recommended of the amended constitutions and by-laws of (1) the Pennsylvania Sewage Works Association, as amended August 29, 1946, (2) the Canadian Institute on Sewage and Sanitation, as amended November 3, 1943, (3) the Arizona Sewage and Water Works Association, as amended April 17, 1946, and (4) the Maryland-Delaware Water and Sewage Association, as amended May 16, 1946.

3. Admission of the Sewage Works Section of the Arkansas Water and Sewage Conference as a Member Association of the Federation was recommended, all requirements for such affiliation having been met by the constitution and by-laws adopted on April 16, 1946.

4. Board approval of the constitution and by-laws adopted on March 8, 1946, by the Kansas Sewage Works Association was recommended, this affiliate replacing the dissolved Sewage Works Section of the Kansas Water and Sewage Association.

5. Admission of the proposed Kentucky-Tennessee Sewage Works Association as a Member Association was recommended, contingent upon the adoption of the constitution and by-laws that has been reviewed and approved by the Committee.

6. Temporary admission of the Sewage Works Section of the Louisiana Conference on Water and Sewerage was recommended should such action be requested by the Executive Committee of the Conference, full affiliation to be considered upon submission of the constitution and by-laws.

7. Continuation of the temporary affiliation of the Oklahoma Water and Sewage Conference was recommended, pending the anticipated submission of a satisfactory constitution and by-laws.

8. Extension of membership privileges to the Water and Sewage Works Association of Brazil was recommended in the event that organization's developments reach a stage where such action would be appropriate.

By motion seconded and carried, the report was approved with all recommendations. A supplementary motion, duly seconded and carried, instructed the Executive Secretary to inform those engaged in the organization of the Water and Sewage Association of Brazil, the Alabama Water and Sewage Works Association and the proposed Virginia Industrial Waste and Sewage Works Association that the Board welcomes their applications for admission into the Federation and will approve such affiliation upon the submission of constitutions and by-laws meeting with the approval of the Organization Committee.

The Executive Secretary presented applications for Associate membership as made by (1) the Pittsburgh Pipe Cleaner Company of New York, (2) Public Works News and (3) the DeLaval Steam Turbine Company. By motion, seconded and carried, these companies were admitted to the Federation in the grade of Associate Member.

Mr. Orchard presented the following resolution in memory of the late Arthur S. Bedell, second President of the Federation:

> Since the last meeting of this Board of Control of the Federation of Sewage Works Associations, Almighty God in His wisdom has called in death
>
> ARTHUR S. BEDELL
>
> a Past President of this Federation, an Honorary Member and a member of this Board of Control.
>
> In his passing, this Federation has lost a most valuable member. His foresight and vision, his unstinting effort and friendly cooperation in all activities of this Federation played a major part in the progress that has been made toward attaining its objectives.
>
> We, the members of the Board of Control, in meeting assembled in Toronto, on Sunday, October 6, 1946, hereby record our deep sense of loss in the death of this beloved associate, and direct that this resolution be spread on the minutes of the Federation and that a copy be sent to Mr. Bedell's family.

The resolution was seconded and carried unanimously, after which the assembly stood in silence for a moment in respect to the memory of Mr. Bedell.

President Hoskins pointed out that the 3-year term of Charles A. Emerson as Director-at-Large would terminate at the end of this meeting, marking Mr. Emerson's departure from the Board for the first time since the Federation was created. He spoke briefly of Mr. Emerson's long and devoted service, emphasizing the fact that the Federation owed much to Mr. Emerson's personal efforts for the strong position it now enjoys.

Responding, Mr. Emerson expressed his gratification at the manner in which the Federation has developed beyond the most optimistic expectations of its organizers, and stated that its creation as a federation of regional associations has been more than justified by the rapid progress to its present strong position. He went on, however, to say that direct membership in the international sewage works organization was not possible for an individual under the present structure of the Federation and that the time may be at hand to consider revision of this structure to convert the Federation into an international association, with the present member associations continuing as local or regional sections. Such a structure would follow the pattern of the other national technical and professional societies. Mr. Emerson submitted this suggestion for the earnest consideration of the General Policy and Executive Committees during the coming year.

Mr. Orchard moved a rising vote of thanks by the Board to President Hoskins and immediate Past President Berry for their efficient leadership of the Federation in the past two years. The thanks of the Board were extended spontaneously and unanimously.

President Hoskins issued a call for a meeting of the 1946 Election Committee to follow immediately the adjournment of this session.

The meeting adjourned *sine die* at 5:15 P.M.

W. H. WISELY,
Executive Secretary

Approved: J. K. HOSKINS, *President*

MINUTES OF MEETING OF 1946 ELECTION COMMITTEE

October 6, 1946

The called meeting of the 1946 Election Committee of the Federation of Sewage Works Associations was called to order by President J. K. Hoskins at 5:20 P.M., October 6, 1946, at the Royal York Hotel, Toronto, Canada.

Roll call was as follows:

PRESENT IN PERSON

Member Association Represented	*Director*
Arizona Sewage and Water Works Association	A. L. Frick, Jr.
California Sewage Works Association	C. C. Kennedy
Canadian Institute on Sewage and Sanitation	R. J. Desmarais
Central States Sewage Works Association	C. C. Larson
Florida Sewage Works Association	David B. Lee
Federal Sewage Research Association	M. Le Bosquet, Jr.
Georgia Water and Sewage Association	H. A. Wyckoff
Iowa Sewage Works Association	J. W. Pray
Maryland-Delaware Water and Sewerage Association	R. E. Fuhrman
Michigan Sewage Works Association	W. F. Shephard
Missouri Water and Sewerage Conference	G. S. Russell
New England Sewage Works Association	L. W. Van Kleeck
New Jersey Sewage Works Association	P. N. Daniels
New York Sewage Works Association	E. J. Smith
North Carolina Sewage Works Association	G. S. Rawlins
Ohio Conference on Sewage Treatment	A. H. Niles
Pennsylvania Sewage Works Association	L. D. Matter
Texas Sewage Works Section	E. J. M. Berg

President Hoskins declared a quorum to exist.

Upon call for nominations to the office of President of the Federation for the year 1946–47, the name of Francis S. Friel (Pennsylvania) was presented by Mr. Matter. There were no further nominations and a motion to close was seconded and carried. The election of Mr. Friel as President was confirmed unanimously by *viva voce* vote and so declared.

Responding to the call for nominations to the office of Vice-President for one year, 1946–47, Mr. Fuhrman presented the name of George S. Russell (Missouri). A motion to close the nominations was seconded and carried. The election of Mr. Russell as Vice-President was confirmed unanimously by *viva voce* vote and so declared.

A request for nominations to the office of Treasurer for the year 1946–47 brought the renomination of W. W. DeBerard (Central States) by Mr. Kennedy. There were no further nominations and a motion to close was seconded and carried. Re-election of Mr. DeBerard as Treasurer was confirmed unanimously by *viva voce* vote and so declared.

Nominations for the office of Director-at-Large for a 3-year term ending in October, 1949, were requested. The name of Anselmo F. Dappert (New York) was presented by Mr. Smith and, there being no further nominations, a motion to close was seconded and carried. Mr. Dappert's election as Director-at-Large was unanimously confirmed by *viva voce* vote and so declared.

All business of the Committee having been completed, the meeting adjourned *sine die* at 5:27 P.M.

W. H. WISELY,
Executive Secretary

Approved: J. K. HOSKINS, *President*

MINUTES OF MEETING OF 1947 BOARD OF CONTROL

October 9, 1946

The organization meeting of the 1947 Board of Control of the Federation of Sewage Works Associations was called to order by retiring President J. K. Hoskins at 2:05 P.M., October 9, 1946, at the Royal York Hotel, Toronto, Canada.

Roll call was as follows, a quorum being represented:

PRESENT IN PERSON

Member Association or Office Represented	*Representative*
President	F. S. Friel
Past President	J. K. Hoskins
Vice President	G. S. Russell
Arizona Sewage and Water Works Association	A. L. Frick, Jr.
Arkansas Water and Sewage Conference	F. L. McDonald
California Sewage Works Association	C. C. Kennedy
Central States Sewage Works Association	C. C. Larson
Florida Sewage Works Association	David B. Lee
Federal Sewage Research Association	M. Le Bosquet, Jr.
Georgia Water and Sewage Association	H. A. Wyckoff
Iowa Sewage Works Association	John W. Pray
Maryland-Delaware Water and Sewerage Association	R. E. Fuhrman
Michigan Sewage Works Association	W. F. Shephard
Missouri Water and Sewerage Conference	G. S. Russell
New England Sewage Works Association	L. W. Van Kleeck
New Jersey Sewage Works Association	P. N. Daniels
New York Sewage Works Association	E. J. Smith
North Carolina Sewage Works Association	G. S. Rawlins
Ohio Conference on Sewage Treatment	A. H. Niles
Pennsylvania Sewage Works Association	L. D. Matter

Member Association or Office Represented	*Representative*
Texas Sewage Works Section	E. J. M. Berg
Director-at-Large	A. F. Dappert
Director-at-Large	F. W. Mohlman
Director-at-Large	H. F. Gray
Water and Sewage Works Manufacturers Association	A. E. Paxton
Water and Sewage Works Manufacturers Association	F. W. Lovett
Publications Committee	F. W. Gilcreas
Sewage Works Practice Committee	M. M. Cohn
Research Committee	W. Rudolfs

PRESENT IN PERSON, ACTING BY PROXY

Member Association or Office Represented	*Representative*
Treasurer	W. J. Orchard (for W. W. DeBerard)
Oklahoma Water and Sewage Conference	C. A. Emerson (for E. R. Stapley)

Also present was W. H. Wisely, Executive Secretary—Editor.

The report of the Election Committee was read, in which were listed the following new officers for the terms indicated: Francis S. Friel—President; George S. Russell—Vice President; W. W. DeBerard—Treasurer (all to serve until October, 1947) and A. F. Dappert—Director-at-Large (to serve until October, 1949).

Assuming the chair, President Friel stated his appreciation for the honor accorded by his election, and expressed hope that his actions during the coming year would justify the confidence placed in him. He asked for the full cooperation of all officers and members of the Board, closing his remarks with the comment that he anticipated an enjoyable year of service as President of the Federation.

Finance Advisory Chairman Orchard presented a revised 1946 budget which took into account the increased costs of current operations reported by the Executive Secretary. This matter had been referred by the 1946 Board. The amended 1946 budget was offered as follows:

Receipts

Membership Dues:	
Active	$10,400
Corporate	240
Associate	1,540
Non-Member Subscriptions	2,200
Advertising 1946 (Net)	14,850
Advertising 1945	320
Net Sale Misc. Publications	1,200
WSWMA Contribution	5,000
Misc. Income	550
	$36,300

Disbursements

Printing and Mailing JOURNAL (Manual No. 2 excluded)	$16,200
Executive Sec. Salary	7,000
Office Salaries	5,400
Travel Expense	1,800
Office Expense	1,100
Rent	720
Editorial Expense	750
Committee Expense	150
Convention Expense	—
Administration Expense	400
Contingencies	200
	$33,720
Balance to Surplus	2,580
	$36,300

Discussing the proposed amended budget, Mr. Orchard pointed out that it included only operating expenses and that the expenditures for office equipment and proposed manuals of practice were not included because such items are more properly chargeable directly against surplus. He then presented a surplus analysis showing the indicated net worth of the Federation at December 31, 1946, as follows:

Accretion to Surplus:

1946 Receipts	$36,300.00
1946 Disbursements	33,720.00
Profit to Surplus	$ 2,580.00

Charges to Surplus:

Manual No. 2	$ 3,000.00
Office Equipment	440.00
Total Charges	$ 3,440.00
1946 Indicated Profit	2,580.00
Net Reduction of Surplus	$ 860.00
Net Worth Dec. 31, 1945	$32,293.01
1946 Indicated Reduction of Surplus	860.00
Indicated Net Worth Dec. 31, 1946	$31,433.01

At this point Mr. Orchard referred to a preliminary financial statement on the Nineteenth Annual Meeting, and reported that indications were that the convention receipts would be sufficient to cover all local and headquarters convention expenses and to yield a clear profit of several hundred dollars, perhaps enough to make up the indicated deficit of $860 in surplus. He commended Dr. A. E. Berry and Mr. J. B. Kinney (Convention Management Chairman and Convention Finance Chairman, respectively) on this fine showing. Mr. Orchard concluded his explanation by predicting that the Federation would maintain in 1946 its surplus balance at the beginning of the year in spite of increased costs of operation, while giving its members a $3,000 manual of practice and adding $440 to its office equipment inventory.

By motion, seconded and carried, the revised 1946 budget and accompanying surplus analysis were adopted.

Consideration was then given to the recommendations of the 1946 Executive Committee in regard to JOURNAL advertising rates and the 1947 budget, these matters having been referred to the Finance Advisory Committee for study and report to the 1947 Board.

In presenting these items, Mr. Orchard emphasized that rising price trends and new services rendered by the Federation are increasing operation costs, while the membership dues remain the same. Cost of printing and mailing the 1946 JOURNAL alone will amount to about $4.30 per member as compared to the annual dues of $3.00. It was further emphasized that the Finance Advisory Committee did not advocate an increase in dues, but that the above fact is significant because revenue from advertising and sale of publications must constantly increase to compensate for the extension of Federation services to an increasing membership. With this in mind, Mr. Orchard suggested that the Board should give serious thought to the furnishing of complimentary copies of all manuals of practice to the membership, a procedure which further complicates the financial picture.

Mr. Orchard read a report of the special committee which had been appointed by Past President Hoskins to cooperate with the Finance Advisory Committee in its study of advertising rates. This report was as follows:

"This special committee, comprising A. S. Paxton, Karl Mann, M. M. Cohn, L. H. Enslow and W. J. Orchard, finds that the present advertising rates do not reflect current costs nor increased circulation, and recommends as of November 1, 1946, an increase in current rates approximating 25 per cent.

"The Committee feels that the discount to agencies is of doubtful value to an official professional publication of this type and recommends that agency discounts be discontinued.

"The Committee feels also that the plan to go on a 12-issue basis should be reviewed. It does not appear that a 12-issue JOURNAL would increase net revenue to the Federation. We feel that the JOURNAL should continue to be strictly of high grade technical and professional content.

"We recommend that the question of a 12-issue JOURNAL be tabled until the Board of Control meeting in San Francisco in July, 1947."

Commenting on this report, Mr. Orchard stated that the Executive Secretary-Editor had expressed willingness to adopt these recommendations in so far as feasible, and that he believed it possible thereby to achieve the net advertising revenue called for in the proposed 1947 budget, as follows:

1947 Receipts

Membership Dues	
Active	$10,500
Corporate	250
Associate	1,600
Non-Member Subscriptions	2,500
Advertising (Net)	17,500
Sale of Misc. Publications (Excluding Manual No. 2)	800
WSWMA (Contribution)	5,000
Misc. Income	550
	$38,700

1947 Disbursements

Printing and Mailing JOURNAL	$16,000
Exec. Secretary's Salary	7,500
Office Salaries	9,700
Office Rent	720
Office Expense	1,200
Travel Expense	2,000
Editorial Expense	250
Administration Expense	300
Committee Expense	200
Convention Expense	500
Contingencies	300
	$38,700

Attention was directed to the fact that this budget was restricted to operating items and did not provide for the $500 of new office equipment or for the cost of publishing manuals of practice in 1947. These extra items, totaling approximately $3,200 (including the Federation's contribution to the Glossary of Water and Sewage Control Engineering), must be charged to surplus.

A motion was made and seconded that the 1947 budget be adopted as proposed.

A lengthy and general discussion on this motion ensued, almost entirely devoted to policy governing the distribution and sale of manuals of practice. The sense of the Board, as revealed by this discussion, was that complimentary copies of Manual of Practice No. 2 (Utilization of Sewage Sludge as Fertilizer) be furnished all current members at the time of distribution, and that prices for extra copies be established that will yield a substantial profit on the venture so as to cover in so far as possible the cost of Manual of Practice No. 3 (Water and Sewage Control Engineering Glossary), for which only a limited outside demand is anticipated.

A vote on the motion to adopt the 1947 budget as presented was taken and the proposal carried unanimously.

A motion was made, seconded and carried that expenditures of $500 for office equipment and approximately $1,500 toward the Federation's share of the cost of the Glossary of Water and Sewage Control Engineering (Manual of Practice No. 3) be authorized from surplus in 1947.

It was moved, seconded and carried that all receipts from sale of manuals of practice be credited to surplus.

By motion, seconded and carried, the Finance Advisory Committee was instructed to study and report on the desirability of establishing a revolving fund from which the cost of all manuals would be charged, and which revenues from sale of such manuals would be credited.

Chairman Fuhrman reported for the Legislative Analysis Committee, which had been directed by the 1946 Board to recommend a Federation policy on federal pollution control. Mr. Fuhrman presented the following statement of policy and moved its adoption:

"The Board of Control of the Federation of Sewage Works Associations hereby records the policy of the Federation on federal water pollution control.

The Federation favors federal legislation:

(1) That will use to the greatest possible extent existing authorities and facilities for the control of water pollution;

(2) That designates the U. S. Public Health Service as the federal Administrative Agency;

(3) That will provide, in the classification of waters, for cooperation and agreement of and between the U. S. Public Health Service and the state pollution control authority, and, where no such state authority exists, the Surgeon General of the U. S. Public Health Service shall integrate the stream classification of such states with the classification of the streams in adjoining or affected states; and

(4) That provides for an Advisory Board with adequate representation of State Water Pollution Control Authorities."

In the discussion which followed seconding of this motion, the preponderance of opinion was favorable to the proposed policy. President Friel called on the several state sanitary engineers present to comment and such representatives from New York, New Jersey, Connecticut, Michigan, Pennsylvania and Florida indicated that the proposed Federation policy was in line with opinion in pollution control agencies of those states. Upon call for the question, the statement of policy was adopted as presented.

President Friel called attention to the suggested schedule of 1947 committees that had been compiled by Past President Hoskins and himself. Several additions to certain committees were suggested by members of the Board, and the following 1947 committee appointments were approved, by motion, seconded and carried:

Constitutional Committees

Executive Committee

F. S. Friel, *Chairman*

Linden Stuart	David B. Lee
G. S. Russell	C. C. Kennedy

General Policy Committee

J. K. Hoskins, *Chairman*

A. H. Niles	R. E. Fuhrman
John R. Downes	M. Le Bosquet Jr.
Dana E. Kepner	D. E. Bloodgood

Publications Committee

F. W. Gilcreas, *Chairman*

W. H. Wisely	Carl E. Green
F. W. Mohlman	F. M. Veatch
Rolf Eliassen	C. C. Larson

Organization Committee

Earnest Boyce, *Chairman*

C. R. Compton	R. H. Suttie

Sewage Works Practice Committee

Morris M. Cohn, *Chairman*

W. H. Wisely, L. W. Van Kleeck, F. W. Mohlman, F. W. Gilcreas, C. E. Keefer, R. F. Brown, G. P. Edwards, K. V. Hill, H. F. Gray, D. E. Bloodgood, J. J. Wirts, Willem Rudolfs, J. R. Downes, F. M. Veatch, A. H. Niles, C. W. Klassen, Langdon Pearse, K. L. Mick

Research Committee

Willem Rudolfs, *Chairman*

H. E. Babbitt, A. L. Genter, D. E. Bloodgood, H. J. Miles, G. P. Edwards, F. W. Mohlman, H. A. Faber, C. C. Ruchhoft, A. J. Fischer, L. R. Setter, H. Heukelekian, L. W. Van Kleeck

Joint Committees with Other Associations

Nomenclature Committee

C. J. Velz, *Chairman*

C. A. Emerson, C. E. Keefer

Standards Methods Committee

W. D. Hatfield, *Chairman*

G. E. Symons, W. S. Mahlie, S. E. Coburn, M. Starr Nichols, A. J. Fischer, Richard Pomeroy, G. P. Edwards, C. C. Ruchhoft, E. W. Moore, Willem Rudolfs, D. E. Bloodgood, H. W. Gehm, F. W. Gilcreas, H. Heukelekian, E. F. Hurwitz, R. D. Hoak, Keeno Fraschino, Roy F. Weston

Committee on Water and Sewage Works Development

C. A. Emerson, G. F. Schroepfer

Special Convention Committees

Meeting Place Committee

F. S. Friel, *Chairman*

G. S. Russell, A. E. Paxton, J. K. Hoskins, W. C. Sherwood, W. H. Wisely, A. T. Clark

Publicity and Attendance Committee

L. H. Enslow, *Chairman*

M. M. Cohn, A. Prescott Folwell, E. J. Cleary, J. P. Russell, Wm. S. Foster, J. A. Daly

Convention Management Committee

W. J. Orchard, *Chairman*

A. T. Clark, C. C. Kennedy, F. S. Friel, W. H. Wisely

Other Special Committees

Awards Committee

E. S. Chase, *Chairman*

G. M. Ridenour, H. W. Streeter, Fred Merryfield

Operation Reports Committee

H. E. Babbitt, *Chairman*

G. A. Hall, W. A. Allen

Finance Advisory Committee

W. J. Orchard, *Chairman*

J. K. Hoskins, F. S. Friel

Industrial Wastes Committee *

F. W. Mohlman, *Chairman*

D. E. Bloodgood, L. F. Oeming, H. W. Gehm

Legislative Analysis Committee

Ralph E. Fuhrman, *Chairman*

Earnest Boyce, W. B. Hart, L. D. Matter, Morris M. Cohn, C. G. Gillespie, V. M. Ehlers, L. F. Warrick

Operator's Qualifications Committee

L. W. Van Kleeck, *Chairman*

Wm. A. Allen, E. P. Molitor

Honorary Membership Committee

G. J. Schroepfer, *Chairman*

A. M. Rawn, J. K. Hoskins, A. E. Berry, F. S. Friel

Nominating Committee

C. A. Emerson, *Chairman*

G. J. Schroepfer, A. E. Berry, A. M. Rawn, J. K. Hoskins

Quarter Century Operators Club Committee

Frank W. Jones, *Chairman*

S. E. Coburn, H. W. Streeter

Next in the order of business was the designation of depositories for Federation funds in 1947. It was moved, seconded and

* Additional appointments to be made by Chairman.

carried that the three banks currently holding Federation funds, *i.e.*, Busey First National Bank of Urbana, First National Bank of Champaign and Continental-Illinois National Bank and Trust Company of Chicago, be continued as depositories during the year 1947. A supplementary motion, seconded and carried, authorized the proper officers of the Federation to withdraw funds as set forth in the budget.

Affirming the action of the 1946 Board, a motion was made, seconded and carried authorizing the Finance Advisory Committee to select the auditing firm to conduct the annual audit as of December 31, 1946.

The next item on the agenda was the consideration of the locations of the 1948 and 1949 annual meetings. President Friel introduced this matter by announcing for the record that the concurrent meeting of the Federation with the 1947 conference of the American Water Works Association at San Francisco during the week of July 21, 1947, had been approved by letter ballot of the Board by a vote of 34 in the affirmative as against 4 opposed. He pointed out that an invitation from the Rocky Mountain Sewage Works Association for a meeting in Denver in 1948 or 1949 was in the hands of the Meeting Place Committee, and asked that any other invitations be presented at this time. Director A. H. Niles, representing the Ohio Conference on Sewage Treatment, presented an invitation for the Federation to meet in Toledo; Director W. F. Shephard presented for the Michigan Sewage Works Association an invitation to meet at Detroit and Director L. W. Van Kleeck extended an invitation from the New England Sewage Works Association for a meeting to be held at Boston. It was moved, seconded and carried that the member associations extending invitations be advised of the appreciation of the Board, and that the selection of the 1948 and 1949 meeting places of the Federation be referred to the Meeting Place Committee, with power to act.

Mr. Orchard called attention to the action of the 1946 Board on October 17, 1945, in appointing the Executive Secretary-Editor for the fiscal years of 1946 and 1947 at a salary of $7,000 for the fiscal year of 1946. He moved that the salary of the Executive Secretary-Editor be established at $7,500 for the fiscal year of 1947, as set forth in the budget. The motion was seconded and carried.

Mr. Larson commended the efforts of the Executive Secretary-Editor and moved that he be given a rising vote of appreciation. This action was extended most graciously.

Mr. Emerson reported that he had discussed with several members of the Quarter Century Operators Club the action taken by the Board on October 6 in regard to the permanent organization of the club. He stated that the club members were deeply appreciative of the Board's interest, and that recommendations for procedure would be forthcoming in due course.

It was moved by Mr. Wyckoff that the sincere thanks of the Board be extended to the Canadian Institute on Sewage and Sanitation and to all individuals who had participated in arrangements for a very successful Nineteenth Annual Meeting. The motion was seconded and carried unanimously.

Adjournment to the next annual meeting or to call of the President was moved, seconded and carried at 4:10 P.M.

W. H. WISELY,
Executive Secretary

Approved: FRANCIS S. FRIEL, *President*

REPORT OF EXECUTIVE SECRETARY-EDITOR

Year Ended September 30, 1946

The record of the Federation during the past year has been highly satisfying in that the gains of recent years in membership and financial position have been maintained in rate, while there has been a marked acceleration in activities and in opportunities for service. The increased interest and participation of the Member Associations and individuals in Federation affairs is a natural result of the end of the war.

Commenting on one problem that arose during 1946, a Past President of the Federation aptly stated that the matter in question was merely a normal "growing pain." The fact that there was a problem or "pain" is unimportant, for these will always be extant in an active organization. It is a good sign, however, that the only problems of the growing Federation today appertain to the meeting of new and greater obligations and responsibilities.

Administrative Functions

The Executive Secretary was directed by the Board at the Eighteenth Annual Meeting to carry out several instructions, all of which have been given attention. In addition to the matters listed here, reference is made elsewhere in this report to the performance of other directives:

(1) The chairmen of the Joint Committee engaged in preparing the Glossary of Water and Sewage Control Engineering were advised under date of October 30, 1945, of the Board's desire that the term "sewage works" be designated as the comprehensive term denoting the collection, treatment and disposal of sewage.

(2) Cost and other data regarding suitable emblems symbolizing the Federation's Eddy, Gascoigne and Emerson awards were furnished to the Awards Committee under date of May 22, 1946.

(3) The AWWA statement of policy concerning conduct of Member Association meetings and the Board's endorsement of the "Club Room" type of entertainment at such meetings (as recommended by the WSWMA) were transmitted to Member Association secretaries under date of November 15, 1945.

(4) A certificate of recognition to be presented to all Past Presidents of the Federation was developed under the direction of the Executive Committee.

(5) Letters advising of the Board's reaffirmation and endorsement of the Spence Bill (HR 4070) and its companion measure in the Senate were sent in November, 1945, to each member of the House Committee on Rivers and Harbors and of the Senate Committee on Commerce.

(6) Letters proclaiming the Board's endorsement of the Bailey Bill (HR 3972) were sent to each member of the House Committee on Ways and Means, under date of October 24, 1945.

The Executive Secretary also cooperated wherever possible in furtherance of Federation' committee functions, and extended his best efforts in responding to requests for assistance to individuals. Of the total of 109 individual service inquiries thus handled, 80 were of a technical nature and 29 pertained to personnel placement.

Publications

Sewage Works Journal

The change to the two-column format of the JOURNAL, directed by the Board in 1945, was initiated with the January, 1946, issue. Readership response to the change has been favorable.

The labor and paper situations continue to interfere with scheduled production of the JOURNAL, despite the fact that the first copy for each issue is now sent to the printer ten weeks in advance of the distribution date. It is believed, however, that Lancaster Press is giving excellent service under the circumstances. The paper shortage has necessitated return to the 45-lb. stock of wartime; even so, distribution of the July issue was delayed three weeks on account of late delivery of paper orders.

The Editor furnished complete data to the Publications Committee as basis for its special report on the proposal to increase the frequency of publication of the JOURNAL from bimonthly to monthly. These statistical analyses, with accompanying studies of texts on business journalism, advertising surveys, conferences with journalism faculty representatives, etc., have proved highly informative and beneficial. Several new cost and editorial controls have been applied to production of the JOURNAL as a result.

A gratifying postwar development has been the increased flow of high caliber material received for publication since the middle of 1946. It is already apparent that there will be plenty of good material for the 1947 volume of the JOURNAL and that adoption of the monthly publication schedule may be justified in the near future.

The actual expenditures for printing and mailing of Federation publications in 1946 will obviously exceed the budgeted amount of $14,300; two factors are responsible. First, Lancaster Press requested an increase of approximately 7 per cent to begin with the May issue, to cover in part the increase in wages and paper costs that have taken place in the past four years. Secondly, the acceptance of the NRC report on military sewage works for publication in the September issue completely upset all budget plans for the year, this document being quite lengthy and expensive to print. The professional value of this contribution was considered to outweigh budget considerations at this time, however, and the Editor assumes full responsibility for this decision.

In spite of the retarding influence of (1) the less favorable situation as regards corporation taxes and (2) the uncertainty and delay which becloud the public works construction picture, it has been possible to maintain the sale of advertising space in the JOURNAL at the all-time high level reached in 1945. Paid advertising in the 1945 volume totaled 262⅝ pages; it is estimated that the 1946 total will be in the order of 260 to 265 pages.

The constantly increasing paid circulation of the JOURNAL is a source of satisfaction. At September 30, 1946, the total paid circulation was 4,293, including 3,735 member and 558 non-member subscriptions. This represents a gain of 12.8 per cent for the year.

Back Numbers

The demand by ex-service personnel and foreign subscribers has resulted in the unusually high sale of 790 back numbers of the JOURNAL in the year ended September 30. About 8,500 single copies are in storage, according to the running inventory maintained by Lancaster Press.

Modern Sewage Disposal

All copies of the Federation's Tenth Anniversary Book have now been sold and this publication is no longer available.

Manuals of Practice

A total of 275 copies of Manual of Practice No. 1 were distributed during the year ended September 30, leaving 967 copies in inventory. Of those disposed of, 149 were sold to members at the 25-cent rate and 126 were sold to non-members at the 50-cent rate.

As directed by the Board, the Editor devoted considerable effort to the publication of Manual of Practice No. 2, "Utilization of Sewage Sludge as Fertilizer." This manual has also encountered production difficulties but will be distributed before the end of October, 1946.

At the Eighteenth Annual Meeting, the Executive Secretary-Editor was directed to investigate the availability and cost of ring binders that would be suitable for filing of manuals of practice, to be made available for sale at a nominal price. A special report on this matter has been prepared.

Member Association Activity

Extraordinary attention was given to contacts with existing Member Associations and to the organization of new Federation affiliates during the past year. In attempting to attend a meeting of all those Member Associations not previously visited, the writer has travelled more than 22,000 miles since the Eighteenth Annual Meeting, and it is considered that the value of this representation of the Federation has far outweighed the fact that the year's travel budget has been considerably exceeded. At least one meeting of every North American Member Association has now been visited; those attended since October, 1945 follow:

Missouri W. S. A.	Jefferson City; Sept., 1945
Ohio Conference	Columbus; Nov., 1945
North Carolina S. W. A.	Charlotte; Nov., 1945
Georgia W. S. A.	Atlanta; Dec., 1945
New York S. W. A.	New York; Jan., 1946
Oklahoma Conference	Stillwater; Jan., 1946
Kansas S. W. A.	Topeka; March, 1946
Arkansas Conference	Fayetteville; April, 1946
Arizona S. W. W. A.	Tucson; April, 1946
Pacific Northwest S. W. A.	Gearhart, Ore.; May, 1946
Florida S. W. A.	Gainesville; June, 1946
Central States S. W. A.	Lafayette, Ind.; June, 1946

Other meetings attended as the Federation's representative were the Illinois Sewage Works Operator's Conference at Springfield in November, 1945; the Purdue Industrial Wastes Conference at Lafayette, Ind., in January, 1946; and the Illinois Association of Sanitary Districts at Peoria in June.

Cooperating with the Organization Committee and aided measurably by the active participation of President Hoskins, the Secretary devoted considerable effort to the development of new Member Associations. The affiliation of the Sewage Works Section of the Arkansas Water and Sewage Conference was one result; new associations were formed during the year in Alabama and Brazil with the intention to affiliate with the Federation; a new Kentucky-Tennessee Sewage Works Association is expected to be formed in October; a new association is in formation in Virginia; and the Louisiana Conference may complete its affiliation before the end of the year. A suggested "model" form of constitution and by-laws has been prepared and approved by the Organization Committee for guidance of those engaged in the formation of new associations.

Toward the end of standardizing procedures of Member Association secretaries, a manual of duties and recommended practices was compiled and distributed early in the year. A new venture, the "Secretary's Manual," has already proved effective in expediting operations at Federation headquarters. The first edition will be brought up to date as necessary.

The 1945 Board directed that each Member Association secretary be sent (1) the AWWA statement of policy regarding conduct of section meetings, (2) the recommendations of the WSWMA regarding the "Club Room" type of entertainment, as endorsed by the Board and (3) a recommendation that interested persons from adjacent non-member states be invited to Member Association meetings, as a means of stimulating organizational activities in such non-member states. All of these instructions were carried out immediately following the Eighteenth Annual Meeting.

Membership

Admission to the Federation of the Sewage Works Section of the Arkansas Water and Sewage Conference brings the total of affiliated associations to 28.

One of the most satisfying gains of the year was in the aggregate membership of the Member Associations. The total of 3,658 Active and Corporate members at September 30, 1946, represents a gain of 13.8 per cent for the year ended on that date. A detailed membership breakdown is given in Table 1. The association secretaries and membership committees are deserving of great credit for this fine record. It is of interest to note that only about 10 per cent of the 1945 members failed to renew for 1946, and that 800 new members and reinstatements were added to the association rosters.

Membership prizes of $100 each were authorized at the Eighteenth Annual Meeting to be presented to (1) the Member Association recording the greatest percentage increase in membership during the year ended September 30, 1946, and (2) the Member Association recording the greatest numerical increase in membership during the same period. The percentage increase prize was won by the Oklahoma Water and Sewage Conference, by its gain from 10 to 33 members, an increase of 230 per cent. The numerical increase prize was closely contested by the New England, New York, Ohio, Pennsylvania and Canadian associations, the final outcome being in doubt until the very last day. By gaining from 223 to 313 members, an increase of 90, the Canadian Institute on Sewage and Sanitation earned the numerical increase prize.

Membership in the Associate Member classification increased by one during the year, the present total being 77.

Financial

As specified in Article IV, Section 5 of the By-laws, each member of the Board is furnished with statements of receipts and disbursements as of December 31, 1945, March 31, 1946, and June 30, 1946. The data for the fiscal year of 1945, together with the balance sheet, were taken from the annual audit. A statement of receipts and disbursements and a balance sheet as of September 30, 1946, are made a part of this report.

The financial progress of the Federation in recent years is shown in the following:

Date	*Net Worth*
December 31, 1940	$ 3,075.78
December 31, 1941	7,089.54
December 31, 1942	13,489.73
December 31, 1943	21,981.73
December 31, 1944	25,863.52
December 31, 1945	32,293.01

Acknowledgments

The progress made by the Federation during the past year would not have been possible without the active interest and cooperation of President Hoskins, Mr. Friel, Mr. DeBerard and Dr. Mohlman; of all committee chairmen and personnel; of the Member Association secretaries and directors; of the officers of the WSWMA; and of the many other individuals who participated and contributed to Federation activities.

Respectfully submitted,
W. H. WISLEY,
Executive Secretary-Editor

TABLE 1.—Summary of Membership as at September 30, 1946

FEDERATION MEMBERS

Honorary	7
Associate	77
Member Associations	28
Active Members	3,595
Alternate Active Members	31
Corporate Members	25

NET MEMBERSHIP OF MEMBER ASSOCIATIONS

Member Association	Total Active and Corp. Members*		Numerical Increase	Per Cent Increase
	Sept. 30, 1945	Sept. 30, 1946	1945–1946	1945–1946
Arizona	24	32	8	33.3
Arkansas**	—	4	4	—
California	300	326	26	8.7
Canadian Inst.	223	313	90	40.1
Central States	563	579	16	2.8
Dakota	45	39	−6	—
Federal	98	125	27	27.6
Florida	70	75	5	7.1
Georgia	65	50	−15	—
I.S.E. (England)	34	34	—	—
I.S.P. (England)	106	121	15	14.1
Iowa	43	41	−2	—
Kansas	28	21	−7	—
Maryland-Delaware	29	35	6	20.7
Michigan	127	136	9	7.1
Missouri	41	55	14	34.2
Montana	31	34	3	9.7
New England	172	225	53	30.8
New Jersey	87	89	2	2.3
New York	493	539	46	9.3
North Carolina	50	50	—	—
Ohio	108	188	80	74.0
Oklahoma	10	33	23	230.0
Pacific Northwest	101	110	9	8.9
Pennsylvania	216	286	70	32.4
Rocky Mountain	61	51	−10	—
San. Eng. Div. (Arg.)	6	—	−6	—
Texas	85	68	−17	—
Totals	3,216	3,659	442	13.8

* Dual Members, *i.e.*, those belonging to more than one Member Association, credited only to "home" association.

** New member association. Admitted to Federation in October, 1946.

W. J. ORCHARD ELECTED HONORARY MEMBER

In recognition of his long and constructive participation in the organization and development of the Federation, William John Orchard, President and General Manager of Wallace and Tiernan Products, Inc., was elected to the grade of Honorary Member on October 6, 1946. Mr. Orchard becomes the ninth person to achieve this distinction.

The action of the Board of Control in naming Mr. Orchard was in accordance with the recommendations of the Committee on Honorary Membership. The report of the committee, presented herewith, reviews the important contributions made by Mr. Orchard toward the welfare of the Federation:

In recognition of continued and valued service to the Federation of Sewage Works Associations from its inception to the present time, the Committee on Honorary Membership nominates William John Orchard of Maplewood, New Jersey, for election to the grade of Honorary Member.

The Committee finds that Mr. Orchard is eligible under the Constitution, as he is a member in good standing of the New Jersey Sewage Works Association and of the New York State Sewage Works Association and, at the present time, is neither an elective nor an appointive member of the Board of Control.

After graduation from the course in Sanitary Engineering at the Massachusetts Institute of Technology in 1911, Mr. Orchard during the next four years served successively as rodman for the Charles River Basin Commission; as instrumentman for the Boston Metropolitan Water and Sewerage Board; as Assistant in the Engineering Bureau of the Massachusetts State Department of Health; and as Assistant Sanitary Engineer in the New Jersey State Board of Health. In this latter position he was actively engaged in inspection and improvement in operation of sewage treatment plants throughout the State.

In April, 1915, he became associated with Wallace and Tiernan as Sanitary Engineer and through diligence and ability, has risen to his present position of General Manager and as President of Wallace and Tiernan Products, Inc. Throughout his connection with Wallace and Tiernan he has had much to do with the continued development of chlorine equipment and chlorination processes for treatment of sewage and its several specialized applications in the field of water purification.

Because of his active interest in advancements in the art of sewage treatment and his marked business ability, it was only natural that, early in 1927, when the concept of the Federation was being developed by the late George W. Fuller and Harrison P. Eddy and by others still with us, Mr. Orchard should be consulted as to the financial side of the venture. Through his individual efforts enough advertising was pledged to insure issuance of a quarterly JOURNAL by the then embryonic organization.

He served as a member of the Committee of One Hundred, appointed July 15, 1927, and the succeeding Temporary Committee, appointed March 8, 1928, which completed the preliminary organization and launched the Federation.

At the organization meeting of the Board of Control held in Chicago on October 16, 1928, he was elected as one of five Members-at-Large of the Board of Control and also as a member of the Executive Committee and Chairman of the Finance Committee. With exception of one year he continued as a Member-at-Large of the Board of Control until October, 1945, on completion of his three-year term as Director under the new Constitution. Throughout these long years of membership on the Board of Control he served as Chairman of the Finance Committee. In the interim between terms as Director and since retirement from the Board, he has served as Chairman of the special Finance Advisory Committee appointed by the Board.

The Committee believes that the sustained efforts of William John Orchard as a member of the Board of Control through a period of approximately 16 years, and his sound advice on matters of finance, have contributed greatly to the rapid growth and success of the Federation and, therefore, unanimously recommends your favorable action on this nomination.

Respectfully submitted,
COMMITTEE ON HONORARY MEMBERSHIP
C. A. EMERSON, *Chairman*,
G. J. SCHROEPFER
A. M. RAWN
A. E. BERRY
J. K. HOSKINS

1946 FEDERATION AWARDS

In an impressive ceremony at the Federation Dinner, held as part of the 19th Annual Meeting at Toronto, the 1946 recipients of the various Federation awards were presented with certificates betokening their recognition. Past President Hoskins officiated at this function, assisted by Past President Berry, Past President Emerson, President Friel and Dr. W. D. Hatfield.

The 1946 awards, as recommended by the Committee on Awards and confirmed by the Board of Control on October 6, are as follows:

Harrison Prescott Eddy Award

The Eddy award for outstanding research, as reported in SEWAGE WORKS JOURNAL, was granted to H. Heukelekian, Associate Professor at Rutgers University, in recognition of his series of papers entitled "The Relationship Between Accumulation, Biochemical and Biological Characteristics of Film, and Purification Capacity of a Biofilter and a Standard Filter." These papers were published in Numbers 1 to 4, inclusive, of the 1945 volume of the JOURNAL.

Holding degrees from Robert College of Ankara, Turkey, and from Iowa State College, Dr. Heukelekian has been associated since 1925 with the Department of Water Supply and Sewage Disposal of the New Jersey Agricultural Experiment Station. Although a member of the teaching staff at Rutgers University, most of his time is devoted to fundamental research on sewage and industrial wastes treatment.

George Bradley Gascoigne Award

For his paper "Operation of Sludge Drying and Gas Utilization Units," published in the November, 1945, issue of SEWAGE WORKS JOURNAL, the 1947 Gascoigne award for an outstanding contribution on sewage works operation was granted to LeRoy W. Van Kleeck, Principal Sanitary Engineer, Connecticut State Department of Health.

Mr. Van Kleeck has devoted much of his interest to sewage works operation procedures in the course of his 16 years of service in the Connecticut Department of Health, and has made many contributions to the literature on this subject. He also served as chairman of the committee which compiled the manual of practice "Operational Hazards in the Operation of Sewage Works," the first of the series to be published by the Federation.

Charles Alvin Emerson Award

Given for "outstanding service in the sewage works field, as related particularly to the problems and activities of the Federation," the 1947 Emerson award was conferred to F. Wellington Gilcreas, Assistant Director of the Division of Laboratories and Research of the New York State Department of Health. The recommendation of the Committee on Awards cited Mr. Gilcreas for "his contributions to the knowledge of sewage treatment practices; his service in the organization of the Federation and his unwavering loyalty to its welfare."

Mr. Gilcreas has participated heavily in Federation committee functions, having served since 1941 as chairman of the Publications Committee. He has also served since 1941 on the Sewage Works Practice Committee as chairman of the chlorination subcommittee and as member of the fertilizer subcommittee, and has been for many years a member of the Committee on Standard Methods.

Kenneth Allen Awards

Nine Member Associations were eligible in 1946 to recognize individuals who have rendered outstanding service by nominating them for the Federation's Kenneth Allen Award. The recipients of these awards are listed herewith:

Recipient	*Association*
E. J. M. Berg	Texas Sewage Works Section
Thomas J. Doyle	Michigan Sewage Works Assn.
John R. Downes	New Jersey Sewage Works Assn.
John Henry Garner	Institute of Sewage Purification
Harold Benedict Gotaas	North Carolina Sewage Works Assn.
William P. Hughes	Pacific Northwest Sewage Works Assn.
Theodore R. Lovell	Iowa Sewage Works Assn.
George Martin	Central States Sewage Works Assn.
Frank E. De Martini	Federal Sewage Research Assn.

OKLAHOMA AND CANADA WIN MEMBERSHIP AWARDS

For the second year in succession, the Canadian Institute on Sewage and Sanitation has won the $100 prize given by the Federation to the Member Association recording in one year the greatest numerical increase in membership. After earning the 1945 prize by adding 72 members in that year, the Institute accelerated the momentum of its campaign to add another 90 members in the year ended September 30, 1946, to win in a spirited finish over the Ohio, Pennsylvania, New England and New York associations.

This was the best contest of any yet sponsored by the Federation. The Canadian Institute held a slight lead throughout the year until early September, when Pennsylvania forged ahead, with Canada, Ohio, New England and New York in close pursuit. This status held until the last day of the contest, when additional lists were received from every one of the leaders. When the smoke cleared, the Canadian Institute was at the top with its increase of 90 members, followed by Ohio with an increase of 80, Pennsylvania with 70, New England with 53 and New York with 46. By its activity in the past two years, the Canadian Institute has more than doubled in size, gaining from 151 to 313 in membership.

The percentage prize, also in the form of a $100 cash award, was gathered in easily by the Oklahoma Water and Sewage Conference. Under the leadership of Grover L. Morris, Sanitary Engineer in the Oklahoma State Department of Health, the Conference increased its membership from 10 to 33, a gain of 230 per cent. The Conference took a long lead in this contest in January, 1946, and maintained it without difficulty. The Ohio Conference, second in the numerical increase contest, was also second in the percentage increase race with a gain of 74 per cent. Other good showings were made by the Canadian Institute (40.1 per cent), Missouri (34.2 per cent), Arizona (33.3 per cent), Pennsylvania (32.4 per cent), New England (30.8 per cent), Federal (27.6 per cent), and Maryland-Delaware (20.7 per cent).

The 1947 membership contests have been authorized on the same basis and under the same rules as those conducted in 1946. The rules are published in THIS JOURNAL, 18, 1, 160 (Jan., 1946).

SPECIAL TRAINS ARRANGED FOR SAN FRANCISCO MEETING

For the benefit of those who are planning to attend the Twentieth Annual Meeting of the Federation in San Francisco next July 22–24, a joint Transportation Committee is arranging for special facilities that will accommodate members of both the Federation and AWWA. The committee is under the chairmanship of E. A. Sigworth.

The special train from New York will be routed through Philadelphia, Harrisburg, Pittsburgh, Columbus, Indianapolis, St. Louis and Kansas City. Plans are being made with other railroads so that people from other sections of the country can join the special train at the various junction points. Wherever possible, full cars will be made up so that they can be switched to the special train at the junction points, thus avoiding individual transfers.

Plans are being made for a stop-over of one day and two nights either at Colorado Springs or Rocky Mountain National Park, depending upon the ability to make arrangements. Sight-seeing tours will be scheduled. After leaving Colorado the party will travel through the Royal Gorge, and then to Salt Lake City where an entire day will be devoted to scheduled sight-seeing tours. Time required from New York is 6 days.

Alternate A trip to San Francisco provides for a direct trip to San Francisco without stop-over, and requires 3½ days from New York.

The special train returning from San Francisco provides for a direct trip back through Chicago without stop-overs, and requires 3½ days to New York.

Alternate B trip returning provides for travel to Portland and Seattle for conducted tours in both cities, and thence to Glacier National Park, where the party will spend two or three days. This trip requires 9 days from San Francisco to New York.

It is necessary for the committee to request hotel accommodations in Colorado and in Glacier National Park promptly, because of heavy tourist travel at that time of year. If requests exceed the accommodations which can be secured, preference will be given in the order in which requests are received by the committee. If deposits are required to hold room reservations, each applicant will be notified.

Expenses

These tours, with the exception of Alternate A, will be worked out on an all-expense tour basis. Charges will cover all expenses except while in San Francisco, and any extra tours or activities other than actually scheduled. Based on present rates, the trip on the special train going and returning will cost approximately $350 per person from New York, and going on the special train and returning on Alternate B will cost approximately $450 per person from New York. Estimates are based on compartment occupancy by two persons. Rates would be in proportion for other types of accommodations and for other points of departure.

Air Travel

The transportation committee is willing to cooperate with any member desiring to fly to or from San Francisco. If sufficient requests are received, consideration will be given to chartering a plane for the trip.

Reservations

In order to complete the above arrangements, all those desiring to take advantage of the planned accommodations should direct a letter to Mr. E. A. Sigworth, Chairman of Transportation, Suite 1333, 230 Park Avenue, New York 17, N. Y. The letter should indicate which trips are preferred as well as the type and number of train accommodations desired.

TECHNICIANS SOUGHT FOR DUTY IN GERMANY

The Office of Technical Services of the U. S. Department of Commerce, charged with the duty of procurement and dissemination of German scientific data and reports, requires the services of several competent and experienced specialists for temporary foreign assignments. The work will involve special engineering and utilities investigations, including studies of German practice in sewage treatment, handling of industrial wastes and stream pollution control.

Salary rates will range from $5,902 to $7,102 in the grades of P–5 and P–6, U. S. Civil Service rating. In addition thereto, adequate allowance is made for maintenance while on foreign duty.

Willingness to sign up for a twelve month period is required. Candidates should be conversant with the German language in reading, writing, and speaking and in the use of German technological terms. A candidate should prepare Civil Service Forms No. 57 in duplicate.

As an alternate proposition, the policy of inviting United States industrial and utility firms to send over their own employee experts and specialists at the expense of the present employers, is being continued by the Office of Technical Services. There is much information still to be investigated with the purpose of bringing significant data to this country. The procedure in having these experts sent to Germany also involves the preparation and submission of Civil Service Forms No. 57.

Applicants should send the fully completed forms to Warren E. Darrow, Chief of Utilities Section, Technical Industrial Intelligence Division, Department of Commerce, Washington 25, D. C. These papers will be processed and the candidate notified when to report.

Reviews and Abstracts

Edited by Gladys Swope †

Allegheny County Sanitary Authority,

4501 Center Ave., Pittsburgh 13, Pa.

Growth and Distribution of Film in Percolating Filters Treating Sewage by Single and Alternating Double Filtration. By T. G. Tomlinson. Presented at a Meeting of the Midland Branch, The Institute of Sewage Purification, held at Birmingham, England, May 14, 1946.*

Within recent years many new modifications in the operation and design of percolating filters used in the purification of sewage and other waste waters have been developed with the object of increasing the volume of liquid treated per unit volume of filter. In most cases the accumulation of film in the interstices of the filter during the colder months of the year limits the rate at which liquid can be applied to the filter. This paper is an investigation of this limitation.

The rate at which film accumulates or is removed is controlled by three main factors —(1) the rate of growth of the component organisms of the film and the deposition of sewage solids, (2) the breakdown of the film by scouring metazoa, mainly worms and insects, and (3) the scouring action of the liquid flowing through the filter. In addition the vertical distribution of the film is an important factor.

Parallel observations were made on a single filter treating settled sewage at rates of 72 to 96 gal. per day per cu. yd. of filtering medium and on two additional filters operated as alternating double filters at two to three times the rate of application on the single filter. It was found that the period of alternation (time as primary or secondary filter) gave similar characteristics for periods of 3½, 7, and 14 days.

The seasonal variation in concentration of film at the surface of the single and alternating double filters was compared by placing cylindrical vessels, 6½ in. in diameter and 4 in. deep with perforated bases and filled with smooth pebbles 1 in. in size, on the surface of the filter in the path of the jets of the rotating distributor, from which they were supplied with sewage. The level of accumulation of film was high during the winter and low during the summer. This decomposition of film during the early summer and the maintenance of film at a low level during the summer is carried out largely by the larvae of the filter flies, *Anisopus fenestralis* and *Psychoda alternata*. The variation in the numbers of larvae in the filters can be judged by the ratios of the numbers of adults trapped during the winter and summer; these were, *Anisopus fenestralis* 1:5; *Psychoda alternata* 1:1,000. The decrease in rate of growth of film during the winter is more than compensated for by the decline in population of insect scourers.

The maximum amounts of film which accumulated in the vessels on the single filter were about 50 per cent greater than the corresponding values for the vessels on the alternating double filters. However, total fungal growth was present in a greater amount in the alternating double filter as it extended to about 3 ft. below the surface, whereas in the single filter, fungal growth was mainly confined to the top of the filter.

This is an explanation of the increased efficiency of filters operated by the method of alternating double filtration. Ponding and clogging of this type of filter may be avoided for constant rates of flow as high as possibly four times the rate that is possible with single filtration.

Robert P. Lowe

* A preprint.

† It will be appreciated if Miss Swope is furnished all periodicals, bulletins, special reports, etc., which might be suitable for abstracting in This Journal. Publications of public health departments, stream pollution control agencies, research organizations and educational institutions are particularly desired.

The Rochdale Kessener Brush Aeration Plant. By D. H. A. Price and I. Withnell. *The Surveyor,* **105,** 523–524 (July 5, 1946).

The construction and method of operating an experimental Kessener brush aeration plant which was constructed in 1944 to treat a daily dry weather flow of 1,600,000 gallons and a maximum flow of 3,900,000 gallons is described. The sewage treated is settling tank effluent derived from a sewage of moderate strength containing wastes from wool scouring, dyeing, tripe dressing, and wastes from a gas works.

The plant consists of six units, each comprising two aeration tanks and four settling tanks.

The aeration tanks comprise two channels, each 96 ft. by 16 ft. with a maximum water depth of 12 ft. 3 in., and provide a nominal retention at dry weather flow of 16 hours.

Aeration is by means of brushes located along the inner wall of each tank and rotating at 140 r.p.m. The brushes consist of stainless steel combs caulked with lead strip into longitudinal grooves in a steel shaft. The brushes touch the surface of the water, setting up, thereby, a current across the tank. This current, when combined with the velocity of the water through the tank, sets up a spiral flow. The aeration is entirely due to surface agitation and entrained air bubbles.

Cross walls, with rectangular openings in the top, are located midway along each tank, forming four bays. The sludge is returned at the inlet to No. 1 bay, but the sewage may be fed into the tank at the inlets of No. 1, 2, and 3 bays, thereby permitting a varying degree of sludge reconditioning. Sewage may also be fed in at the three inlets simultaneously giving "step loading." Effluent from the aeration tanks is withdrawn over a 30-ft. weir, which is adjustable, from just below the lowest brush level to a point 2¾ in. higher. This level, plus the head of the weir, governs the immersion depth of the brushes and hence the intensity of the aeration.

The mixed liquor is settled in four square upward flow settling tanks having a nominal retention of 6 hr. at dry weather flow corresponding to a vertical velocity of 1.62 ft. per hour.

Sludge is withdrawn by gravity from the settling tanks into a channel equipped with a sludge elevating wheel 5 ft. 8 in. in diameter. The wheel is divided into six compartments and rotates at 6 r.p.m. The quantity lifted by the wheel varies with the depth of immersion of the wheel.

A 20 HP motor drives both the aeration tank brushes and the sludge elevating wheel for each set of aeration and settling tanks.

No operating data are included in the article.

K. V. Hill

Disposal Plant to Alleviate Boston Harbor Nuisance. II. Problem of Solids Disposal Solved. By Karl B. Kennison. *Civil Engineering,* **16,** 304–307 (July, 1946).

The Nut Island plant is the first of a series of sewerage projects of the Metropolitan Water Supply Commission. The general scheme and the racks, grit channels, comminutors, low-lift pumps and aeration tanks were described in Part I in the June issue of *Civil Engineering.* (Abstracted in This Journal, **18,** 124 (January, 1947.)

The sedimentation tanks at the Nut Island plant are six in number, each 185 ft. long, 64 ft. wide and 13 ft. average depth. These tanks will be covered. Each tank has four main sludge and scum collectors, one sludge cross collector and one scum cross collector. Alternate tanks have a narrow channel (10 in. wide) in which scum from a pair of tanks is floated to the influent end, thence to the scum pumping station. Each scum channel is hydraulically part of the tank in which it is located, and is separated from the rest of the tank by a side plate only. A flight conveyor is used to move the scum.

A sludge and scum pumping station will be provided for each pair of sedimentation tanks. In each station there will be three 200 g.p.m. pumps, one triplex plunger pump and two "screw-peller" pumps. The capacity of the pumps is such that any two can handle the flow pumping but 15 per cent of the time. Two mains will be provided between the pumping stations and the digesters, with provision for cleaning the lines by means of a "go-devil" type cleaner.

Settled effluent will be returned to the outfall sewer by way of the existing sand catcher and the discharge will be controlled by means of the present control gates. The existing cage-elevator racks will be removed and the space remodeled to house chlorinating equipment.

The existing 60-in. outfall pipes each terminate in a 90° elbow with the open end upward. In order to provide more effective dispersal of the effluent it is proposed to cap the outlet with a 16 ft. diameter flat reinforced concrete dome. This dome will be supported at a suitable distance above the present outlet and will be held in position laterally by means of precast concrete beams arranged radially from the edge of the dome.

There will be four sludge digestion tanks, each 110 ft. in diameter with a side wall depth of 30 ft. Two of the tanks will have fixed covers and will operate as primary units. The other two, secondary units, will have floating covers. Temperatures will be maintained at 90° F. by water circulated from the gas engine cooling jackets. Heat exchangers will be used to control temperatures, using effluent for cooling when heat from the engines is more than required by the digesters, and using steam when the heat demand is more than can be supplied by the engine cooling water. It is estimated that the average daily solids load to the digesters under present conditions will be 51,000 lb. and that the daily gas production will be 525,000 cu. ft.

Digested sludge will be discharged through a 12 in. line laid across the harbor to the deep water in President Roads. Sewage effluent will be pumped through the line continuously. Three pumps will be used for this purpose and they can be operated in series if necessary. Sludge pumps will be started about two hours before high tide so that the entire load of digested sludge will be discharged at the outlet end on the early stages of the outgoing tide. The line will be equipped to take a cleaner of the "go-devil" type.

T. L. Herrick

Refinery Waste Disposal Problems Handled in Special Laboratory. By William F. Bland. *Nat. Pet. News,* Technological Section, 38, No. 10, R-177-80 (March 6, 1946).

The Atlantic Refining Company operates the only laboratory in the petroleum refining industry that is closely devoted to industrial waste investigations. Started about 15 years ago on a small scale it gradually expanded until today it occupies a floor space of 1,500 sq. ft. and has a staff of 3 full-time employees. Plans are now being made to double the facilities and staff to provide for extensive survey and development work. It was in the original, small laboratory that W. B. Hart developed his idea for the oil-water separator which was later adopted by the American Petroleum Institute.

The main duty of the laboratory is to find the wastes being produced in the refineries, the degree of treatment they will require, and the most practicable treatment method that will serve the purpose.

In addition, the laboratory performs the following functions: (1) develops waste treatment equipment and prepares functional designs; (2) supervises waste control and disposal facilities; (3) suggests investigations on waste utilization; (4) conducts investigations and collects analytical data on waste disposal for report to Federal and State agencies; (5) performs limited fundamental research on waste treatment and toxicity; and (6) assists the A.P.I. Committee on the Disposal of Refinery Wastes.

The laboratory has made extensive studies on the toxicity to aquatic life of various refinery wastes, using improved methods developed by the staff. The concentration of a waste which will kill exactly 50 per cent of a number of fish in 24, 48, and 96 hour intervals is determined by exposing the fish at constant temperature in aquaria in which the oxygen concentration is maintained at not less than 50 per cent of saturation. The oxygen level is sustained by bubbling air through the bath except where volatile toxic agents are being tested. In these cases a pure oxygen interface is provided by a special device so that dissipation of the agent by a stream of air is avoided.

Bacteriological investigations are also

made continually, as well as determinations of the limiting concentrations of taste and odor producing compounds.

An intensive investigation of Atlantic's entire waste disposal problem is planned; it will require two to three years for completion. The first job in the program will be a rough survey of the quantities and types of wastes being discharged. Then exact analyses will be made of the wastes where they discharge into public waterways. The analyses will include pH; toxic substances; taste and odor producing chemicals; oil and floating matter; dissolved and suspended solids. Finally, process controls will be instituted and waste treatment methods proposed to the engineering department.

RICHARD D. HOAK

Refinery Waste Disposal: VII. Chemicals Present in Escaping Wastes Can Damage Waters for Many Uses. BY W. B. HART. *Nat. Pet. News*, Technical Section, 38, No. 27, R–512–17 (July 3, 1946).

Water-in-oil emulsions may be lighter or heavier than water, and they usually occur in masses. Composed largely of oil in a cellular structure bound by a septum which is often stabilized by finely divided solid particles, these emulsions are readily broken by wind and wave action, or by friction against any but very smooth surfaces. When ruptured, the released oil forms a film on water, vegetation and structures.

Oil-in-water emulsions consist of minute globules of oil dispersed in water; their oil content is relatively low.

Oil-in-water emulsions have a severe effect on aquatic animals because their absorption into the pores of the animal breaks the emulsion, the oil coats the tissues and prevents gaseous interchange, and death ensues from asphyxiation. This mechanism affects all kinds of animals from microscopic unicellular organisms to highly organized varieties. In addition, dissolved oxygen is consumed by those bacteria which oxidize oils.

Those refinery wastes which contain dissolved chemicals destroy the normal balance of any given body of pure water. Wherever alkalies or mineral acids are discharged to a stream in sufficient quantity, the buffering action of the natural dissolved salts (which holds the pH of the water within narrow limits) is destroyed, and the pH rises or falls sharply.

The influence of pH on aquatic life is a relatively confused matter, and, while it is unquestionably an important factor, there is no clear explanation of its function. Probably, as a result of the nearly uniform pH values in a particular body of water, reasonably constant composition can be expected for the different ecological regions which provide a desirable environment for aquatic life. Very definitely, pH is an index of aquatic environment, and, where its value changes too greatly, forms important to stream cleanliness may be driven away or destroyed. It has been suggested that pH influences the permeability of cell membranes, and the ability of cells to absorb oxygen and transpire carbon dioxide. But, although wide ranges of tolerance to pH have been found, it is clear that all life forms tend to remain in water with a pH to which they are accustomed and to disappear wherever relatively excessive changes occur.

Free acid (or salts with an acid reaction) is a component of several refinery wastes. One of the most spectacular effects of these wastes is corrosion of steel and concrete structures. But free acid releases carbon dioxide by reaction with the alkalinity of the water, and, while part of this gas is lost rapidly to the atmosphere, some remains dissolved in the water. Sensitivity to carbon dioxide varies with different species of fish, but rapid changes in concentration are always serious. Also, fish are more susceptible to the effects of low dissolved oxygen where this is accompanied by a high concentration of carbon dioxide. Acidity tends to prevent self-purification of streams by destroying aerobic bacteria and the microscopic green plants which contribute oxygen. Acidity affects the respiration of fish; it has been shown that the amount of oxygen a fish can utilize per hour per unit of weight, varies with the acidity of the water. In addition, acids are directly toxic to fish, and mineral acidity below pH 4 is corrosive to respirative tissue.

The alkalinity in refinery wastes is usually contributed by sodium carbonate or sodium hydroxide. Its effect on surface water is not normally serious where the pH does not exceed 10. Where higher pH values occur the water approaches causticity and it is unsuitable for a number of industrial uses without pretreatment. Recreational uses of water are affected as the pH increases by preventing bathing, and by corroding structures. Where the buffering action of the water is destroyed at high pH values, damage to aquatic forms occurs through corrosive and toxic effects; microscopic forms are destroyed; cells of larger plant forms are broken down; and the gills of fish become coated with coagulated mucous, which causes death.

Richard D. Hoak

Refinery Waste Disposal: VIII. Refinery Wastes Can Stop Oxygen Supply, Causing Water Pollution and Killing Life. By W. B. Hart. *Nat. Pet. News* Technical Section, **38**, No. 32 R–587–94 (Aug. 7, 1946).

Of all the factors which contribute to the cleanliness of surface waters, dissolved oxygen is one of the most important. It is essential directly for the support of aquatic life, and indirectly to promote the complex reactions of self-purification.

The natural demand on the dissolved oxygen in surface waters is a biochemical one in which oxidation occurs through the medium of bacterial action, with enzymes performing a catalytic function. Certain refinery wastes not only increase the B.O.D. load on the stream, but also impose a chemical oxygen demand. This demand involves three types of chemical reaction which may be illustrated by (a), oxidation of thiosulfate to sulfate and sulfur dioxide; (b), dehydrogenation, as in the oxidation of succinic acid to fumaric; and (c), oxidation of ferrous iron to ferric. These oxidations occur so rapidly that their effects have sometimes been called "immediate" oxygen demand. For example, on one occasion a single barrel of waste caustic discharged to a stream consumed, almost immediately, all the oxygen the stream could carry in 24 hours. In this case the high demand was attributable to a heavy concentration of thiosulfates, sulfites and sulfides, all of which were converted to sulfates at the expense of the oxygen in the stream. These effects are aggravated at elevated temperatures because the reactions are more rapid and the stream contains less oxygen.

Ice cover accentuates the effects of oxygen-consuming matter by preventing gaseous interchange between air and water, and by retarding the penetration of light required for photosynthetic oxygen production. The septic conditions that sometimes occur under ice are not necessarily caused by the discharge of organic matter; a sufficient quantity of oxygen-consuming inorganic matter will produce a similar result.

Refinery wastes which cause tastes and odors are an important form of water pollution. There are 4 phases to the water odor problem: (1) odors from single-celled organisms, and decay of animal or vegetable matter; (2) odors from dissolved chemical compounds; (3) odors from the combination of chemical compounds; and (4) those odors which affect the flavor of aquatic animals used for food.

The first type of odor comes from natural causes, but the others are important in refinery waste disposal. Mercaptans, disulfides, etc., frequently present in refinery wastes, can impose a heavy load on water purification plants, only "rough" fish will stay in water carrying such odors, and, when used for food, such fish have a bad taste. The phenol-like compounds produce a medicinal taste where chlorine is used as a disinfectant, though this odor is sometimes confused with that resulting from the destruction of certain organisms, *e.g.*, synura. The major danger occurs, however, where individuals are driven to drink natural water that tastes better but contains pathogenic organisms.

There are 4 groups of toxic wastes: those which are lethal because they (1) consume oxygen and cause death by asphyxiation; (2) are corrosive to tissues on contact; (3) dehydrate organisms by osmosis; and (4) are poisonous (truly toxic) by absorption after entering an animal through one of the usual openings.

All levels of aquatic life are affected by toxic action, but the poisons in refinery wastes have been studied most often in their effects on fish. Various sulfur compounds are truly toxic, *e.g.*, hydrogen sulfide causes respiratory paralysis. Lethal concentrations of hydrogen sulfide are given in the table:

Lethal Concentrations of Hydrogen Sulfide

Sunfish	5.00 p.p.m.
Brook trout	0.86
Suckers	3.80
Goldfish	4.30
Carp	6.30

It is claimed that 1 p.p.m. methyl mercaptan will kill small game fish in 2 to 6 hours. Phenolic compounds are tolerated to some extent but are definitely toxic because they coagulate mucous secretions, hemolyze blood, and paralyze muscles; their toxicity to fresh water fish has been reported as 1 to 10 p.p.m. Ammonium compounds are highly toxic and are lethal in concentrations of 2 to 13 p.p.m.; their toxicity is aggravated by high alkalinity. Other nitrogen compounds, such as pyridine, are similarly toxic. Chlorine and chloramines are toxic in concentrations of 0.06 to 0.5 p.p.m. All metallic ions, except those of the alkalies and alkaline earths, coagulate gill mucous and cause death by asphyxiation. Some substances that are not themselves toxic may form poisons through chemical or bacterial action, *e.g.*, bacterial action on sodium sulfate to form hydrogen sulfide.

High concentrations of dissolved solids have a serious effect on aquatic life through the effects of osmosis. Where the salt content of an organism is low compared with the surrounding water, the solvent in the organism tends to flow, by osmotic pressure, through its semi-permeable membranes to the water outside, and the organism dies by dehydration. There are some exceptions to this generalization, but the effects of excessive dissolved solids in refinery effluents are important, and are often overlooked. It has been stated that 350 p.p.m. dissolved solids is the upper limit of optimum environmental conditions for most fresh water fish.

Settleable solids (finely divided rock, coke, coal, cinder, clay, etc.) in refinery wastes erode and block pump lines, affect navigation, destroy spawning beds of fish, and degrade recreational areas. In settling, such matter tends to drag down eggs and other life forms supported by vegetation and thus destroys the food supply of larger species. Suspended matter reduces the penetration of light and prevents photosynthesis; light can penetrate excessively turbid water only a few inches, and several refinery wastes can cause this effect where stream dilution is low.

Some refinery wastes produce true colors in a receiving stream. Color is mainly objectionable because of its effect on the penetration of light; the degree of absorption of light increases inversely with its wavelength. The environmental conditions of aquatic life are changed by color, even where their is neither toxicity nor oxygen depletion.

Richard D. Hoak

Refinery Waste Disposal: IX. Oil Savings, Plant Economies are Dividends from Organized Anti-Pollution Program. By W. B. Hart. *Petroleum Processing,* **1,** No. 1, 21–6 (September, 1946).

Where anti-pollution suits have been filed or merely threatened, discussion with management has disclosed a quite vague understanding of the reasons for the complaint, and usually no individual in the plant was given waste disposal as a specific responsibility. In past years industrial management has been generally indifferent about waste treatment. But lately, as pressure from legislation began to be felt, responsibility for pollution prevention has been placed upon those departments causing most of the trouble.

In a few instances separate divisions had been established to handle waste disposal, and the advantages of separate responsibility are now apparent. These are: (1) A single group gives full attention to waste treatment with the burden of operational problems. (2) The group can be made up of specialists in the fields of sanitary and public health engineering, limnology, ecology, physiology, toxicology, and water and sewage treatment chemistry. (3) Such a group can aid management in solving polution problems through familiarity with public agencies and the encouragement of mutual understanding between management and the enforcement agencies. (4) A separate division can engender good relationships within the refinery organization by effecting economies through reduction or elimination of sources of pollution.

Refineries are always short of tank capacity, yet investigation shows that many tanks have not been cleaned for years, and up to 15 per cent of capacity is occupied by "bottoms." Refinery profits are dependent, in large degree, on operations which do not permit waste of product through leakage. Where operators draw down tanks there is frequently a substantial loss of oil to sewers; a waste treatment organization could save considerable money by patrolling areas in which leakage is known to occur.

The nature of an industrial waste division may best be first considered in terms of the small refinery running 500 to 2,500 barrels of crude per day. Such a plant cannot support a large organization, but it should have at least one well-qualified man to assume responsibility for waste treatment. He should be permitted to call on operators for necessary labor, but his source of labor should be such that it is always available for emergencies, and the same men should be chosen each time so they can be properly trained. A small laboratory is absolutely essential; it may be in a separate room, or in a section of the main laboratory, but it must be permanently available. This is the simplest type of organization possible, but, because of its simplicity, it is difficult to administer, through division of responsibility. The complete support of management is absolutely necessary.

In plants of larger size, waste treatment divisions are frequently self-supporting by virtue of their function in preventing waste of product. Such a division may well consist of a supervisor and 2 to 4 operators for the waste treatment plant. Inclusion of a sanitary engineer is often desirable. The largest refineries will require organizations of 40 to 50 men, headed by a superintendent. Technical activities should be handled by a sub-group with a sanitary or a chemical engineer in charge. There will be need for some knowledge of the branches of science mentioned above, permission to attend regularly the meetings of technical associations, and a library of reports on current advances in the field. A separate laboratory is a prerequisite. A large organization needs the support of management just as much as a small one, for waste disposal is rarely popular among operating departments.

The general procedure for attacking a waste disposal problem may be divided into 5 fairly distinct steps. (1) Preliminary groundwork to define the specific problem; (2) general study of the defined problem; (3) development of treatment or disposal methods; (4) design and construction of equipment; and (5) test of plant in operation and survey of effect on surrounding surface waters.

When a pollution complaint is received, the first step should be a conference with the complainant; this approach will seem wrong only to managements ignorant of the significance of water pollution problems. Where the complaint is turned into a controversy, management usually loses the final argument, even in cases where the original complaint was unfounded. The best attitude for management is to exhibit an interest in the complaint and a willingness to do something about it. But undue haste in putting up some kind of treatment plant should be avoided. The whole problem should first be discussed with the appropriate public agency.

Where the subject of pollution is initiated within the refinery a logical procedure should be adopted. It is fundamental that the basic data for treatment plant design are the quantity and characteristics of the wastes in question. A complete survey, which will insure inclusion of maximum flows, should be made and proportionate samples collected, preferably continuously over a 24-hour period. All samples should be collected in glass, except where hydrofluoric acid is involved, when special containers must be used. The analyses should be tabulated and studied to determine any advantage in grouping wastes for separate treatment. Where wastes are to be combined it must be established whether this will result in any change in composition or condition which would interfere with the treatment process; such a contingency is the main reason for piloting the treatment process. Where existing sewers are to be used, they must be checked for flow capacity. Finally, there must be assurance that mixed wastes will not release poisonous or obnoxious gases that would be deleterious to workmen.

(With this issue the Technical Section of National Petroleum News becomes a separate publication: Petroleum Processing. Abs. Note.)

RICHARD D. HOAK

The Treatment of Waste Waters from the Steel Industry. BY CHRISTIAN L. SIEBERT. *Iron and Steel Engineer,* 23 (No. 7), 78–87 (July, 1946).

Acid Pickling Wastes. General. Three methods of treatment are described two of which may be termed utilization processes. "Acid solutions used for pickling ferrous metals are usually wasted when their acid content becomes reduced to about 2–4 per cent but it is surprising to realize that 85–95 per cent of the acid and metals are lost in the dilute wash waters and only 10–15 per cent in the spent pickle liquor."

One method of treatment is to neutralize with lime, followed by aeration and sedimentation. At some works the free acid is exhausted by the addition of scrap steel to the spent pickle liquor, this being followed by evaporation and drying to produce ferrous sulfate. The "Ferron Process" provides "for excess treatment with unsilicated low magnesium lime, heating and agitation and treatment of the resulting slurry in a filter press for extraction of the mixture of calcium sulfate and iron oxide which is extracted from a pug mill in blocks."

Plating and Heat Treatment Wastes. "Plating rinse waters contain about 100 p.p.m. cyanides." Ponding has been used but requires a large area. Some plants have successfully treated the cyanide wastes with acid by adding the acid slowly to the wastes which were contained in a tank equipped with a tight hood leading to a stack with forced ventilation.

Treatment with ferrous sulfate or spent pickle liquor has been used, also with lime-sulfur, or chlorine.

Removal of chromium has been accomplished by precipitating with barium sulfide.

Blast Furnace Dust. Gas scrubber water can be settled in clarifiers from which the sludge may be pumped to ore storage piles where the water is drained away and the iron bearing dust adhering to the ore can be recharged in the blast furnace. One mill installed this type of treatment at a cost of $485,000 but recovers 320 tons (dry basis) of flue dirt daily valued at $5.80 per ton giving a total recovery of $625,000 per year.

Scrubber wastes from producer gas plants contain hydrogen sulfide which may be removed by aeration.

Oil Wastes. "The conventional method of removing oil from waste waters is by gravity flotation separators."

Cutting Compounds. Most of these compounds are emulsions of oil. The vegetable oils and soaps often used in these compounds may exert a B.O.D. of 10,000 p.p.m. Acid cracking and chemical coagulation has been successful in treating these wastes.

Phenols. There are three methods in use for removal and recovery of phenols from coke plant ammonia liquors: (1) steam distillation, (2) solvent extraction and (3) adsorption by activated carbon.

The paper is discussed by R. D. Hoak, C. J. Lewis, Roy F. Weston, W. P. Hill, F. C. Schoen and C. S. Cassels.

GLADYS SWOPE

Polluted Streams Cleared up by Aeration. BY RICHARD G. TYLER. *Civil Engineering,* 16, 348–349 (August, 1946).

Many streams are overloaded to the extent that the dissolved oxygen content is reduced below acceptable values. Reaeration of such streams by artificial means has been suggested and has been tried. The object is not to produce oxidation of the organic matter but to provide an additional source of dissolved oxygen so that the stream can carry on the natural action of self-purification.

Full scale tests have been carried on at Park Falls, Wisconsin, on the Flambeau River which receives sulfite waste liquors. The aeration plant consists of 319 sq. ft. of diffusers set at a depth of about 10 ft. Air is supplied at a rate of about 1,550 cu. ft. per minute. About 1.5 tons of dissolved oxygen were added per day with a stream flow of 880 cu. ft. per sec. During the 1945 season a dissolved oxygen content of 3 p.p.m. or more was maintained at a point 18 miles below the point of discharge of the sulfite waste liquor.

Laboratory tests have shown that reaeration is not effective when applied shortly after the liquor enters the stream. Satisfactory efficiencies are obtained when the aeration is applied 24 hr. after the addition of the liquor. Tests have also shown that the efficiency of aeration varies with the character of the pollutional load of the stream. Aeration applied to sewage polluted streams appears to be more efficient than when applied to streams receiving sulfite waste liquors.

The process might be used to advantage under the following situations:

1. "To rehabilitate streams where pollution has greatly reduced the dissolved oxygen."
2. "To take care of overloads of pollution where existing disposal plant capacity is being overtaxed."
3. "To avoid expensive disposal plant expansion for protecting a stream from increasing B.O.D. loadings.
4. "As a method of secondary treatment."
5. "For joint use by several communities whose disposal plant effluents are overloading the receiving stream."

In situations where extensive sludge deposits deplete the dissolved oxygen reserves such an installation affords the most effective corrective measure.

T. L. Herrick

Fuel and Fertilizer from Sewage—Aim of German Treatment Plants. By A. J. Fischer. *Civil Engineering,* **16,** 448–450 (October, 1946).

During the war sewage treatment had no place in the economy in Germany except where it directly helped the war effort. Recovery of minerals, fertilizer and fuels from sewage and industrial wastes was stressed. Maintenance of plants was neglected. However, some 235 new plants were built, mostly at military establishments or industrial plants.

Digester gas was recovered for use as a motor fuel. It was delivered to customers in containers holding 350 to 560 cu. ft. at a pressure of 200 atmospheres. The purified gas contained 90–94 per cent methane, and about 135 cu. ft. at atmospheric pressure is equivalent to 1 U. S. gallon of gasoline.

Industrial waste treatment methods were similar to those used in the United States. Recovery of valuable constituents in the wastes was stressed, particularly those in phenol, iron, and copper wastes.

In the newer plants unit operations are similar to those in U. S. plants. German designs are more complex. Storm flows are treated in tanks, or to a limited extent by screens. Mechanical cleaners are usually used on bar screens. Grinding of screenings is rare.

Large sludge hoppers are utilized in settling tank designs. Primary settling tanks are generally cleaned mechanically. Plain Dortmund tanks are used to a considerable extent for secondary settling. Hopper bottomed tanks are planned for both primary and secondary settling tanks in an activated sludge plant proposed for Berlin. It was felt that mechanical equipment should be avoided because of the possibility of ice trouble in the tanks, due to the very long sewer leading to the plant.

Another activated sludge plant being designed for Berlin to serve a population of 1,300,000 is to be laid out in three separate groups, each of which is divided into three sections. Treatment in one or more sections would be carried to a high degree of nitrification and the effluent recirculated to the raw sewage entering all three plant groups. This plant was to be mechanically equipped throughout.

Some enclosed, forced down-draft filters have been built, chiefly in the Ruhr district. They are dosed at three to four times the usual rate.

Fish ponds and sewage farms have both been used extensively but are falling into disuse. Chlorine was not used at all during the war and chemical treatment was rare.

One large chemical treatment plant treats the sewage equivalent to a population of 800,000 of which three-fourths is industrial wastes. The process includes carbonation with stack gases, mixing and flocculation with reduced iron sludge, settling, contacting with iron filings, and two stages of activated sludge. It is reported that the B.O.D. is reduced from 1,400 p.p.m. to 10–20 p.p.m.

T. L. Herrick

Current Developments in Waste Utilization. BY HAROLD R. MURDOCK. *Ind. Eng. Chem.*, 38, No. 8, 83–84 (advertising section, August, 1946).

This article is a concise account of wastage in the manufacture of hardwood veneers. The waste in this industry averages 54.2 per cent, as compared with 48 per cent where logs are processed to lumber. Wood scrap is used to fire boilers, and log cores are converted into boards for crates and other cheap wooden products.

RICHARD D. HOAK

The Chemical Engineers' Approach to Industrial Waste Problems. BY JOHN E. TARMAN. *J. Amer. Water Wks. Assn.*, 38, 333–341 (March, 1946).

The operation of substantially all industries results in the creation of waste products that may be liquid, solid or gaseous. Except for a minor number of cases, in which water-carried waste may be discharged into leaching wells for underground disposal, they will eventually find their way into surface waters.

The treatment of water-carried wastes for by-product recovery has become essential in certain industries due to economic competition. The recovered by-products are of sufficient value to the industry to justify certain expenditures for treating facilities and methods.

The treatment of industrial trade wastes is therefore rapidly becoming a process problem. Trade waste treatment and disposal must be considered at any time a plant location is being selected or a particular manufacturing or processing operation contemplated. The cost of such disposal facilities and methods must be considered as an operating cost of the particular plant or process involved. Recovery of usable and valuable by-products will, in many cases, at least partially offset the cost of the treatment, but it cannot be counted upon to offset the entire cost.

Variations in industrial wastes require that every industrial waste problem receive individual study and evaluation before a satisfactory and economic solution can be evolved. The wastes in question from industries can be roughly classified as organic or chemical for purposes of study and treatment.

In any individual study of waste treatment, investigation of the plant process should be the first step. In many cases, the quantity of material lost from a certain process will be almost a direct function of the flow of water leaving the process. By minimizing the flow of water, therefore, the wastage of the product may also be minimized. Re-use of water with or without treatment can often reduce the total amount of product lost in water-carried waste. In any case, internal plant studies will be most effective if made by chemical engineers experienced in waste treatment work in cooperation with engineers familiar with the particular plant and its process problems.

After all possible internal plant changes have been made or designed to effect waste reduction to a minimum, the characteristics and quantities of waste leaving the plant must be determined. This is accomplished by taking the necessary flow measurements and conducting the required analytical work. In some cases it will be found possible to discharge wastes through the city sewerage system either direct or after pre-treatment, and this will undoubtedly be found to be more economical and simple. In other cases either primary or complete treatment will be required for disposal directly to a receiving body of surface water.

To separate the liquid and solid components any one or several of the mechanical separating arrangements may be applied. Screening, settling, settling and skimming, and filtering for further clarification or dewatering of the solids, may be used. Various methods of centrifuging or flotation may be also used for separation. The application of a vacuum to a sedimentation tank to accomplish both settling and flotation in the same unit is a recent development and will probably find more widespread use in the future for industrial wastes. Evaporation, either of the solar type in lagoons or by mechanical evaporators, may be particularly applicable if a by-product can be recovered. In some cases adsorption, as on activated carbon, may be applied.

Sludge disposal may be accomplished by solar or mechanical drying, and incineration or other means of final disposal.

Final decision on sludge drying methods and the use of incineration can be based only upon detailed economic considerations of the several factors prevailing in any specific problem.

Chemical flocculation and precipitation find application in the treatment of certain industrial wastes, either alone or followed by other treatment. Neutralization of highly acid or highly alkaline wastes by compounding plant wastes may be sufficient in some cases. In other instances some acid or alkali feed may be required entirely or in part to supplement compounding plant effluents. Industrial wastes which contain highly oxidizing or reducing components may require neutralization of these factors prior to discharge, but this is employed only in special cases.

Biological treatment may be through aerobic action in trickling filters or in the activated sludge process. Anaerobic biological treatment is normally confined to the treatment of sludge resulting from some other process.

From the foregoing, it will be apparent that the successful treatment of an industrial trade waste will depend on the application of the appropriate unit process or process to the special problem as presented.

ROBERT P. LOWE

Water Quality and Pollution Control in Western Pennsylvania. By C. H. YOUNG. *J. Amer. Water Wks. Assn.,* 38, 511–524 (April, 1946).

For the most part, this paper covers the twelve northwestern counties of Pennsylvania. The Lake Erie, Beaver River, Allegheny River and Lower Ohio River (in Pennsylvania) drainage basins exist in this section. All have a higher population density than the average for the entire Ohio River basin, which is 92 per square mile. Also there is a wide variety of industries which include mining, chemical plants, milk processing and manufacturing, oil production and refining, metal works, distilleries, paper, steel and allied plants, tanneries, etc.

The Lake Erie Basin is the smallest in this district, yet it has the highest population density (296 per square mile). All municipal sewage discharged in this basin is treated, and a number of industries treat their wastes. However, further improvement is required in connection with a limited number of industries discharging waste waters. There is no mining in this basin.

The Beaver River basin has a problem that is complicated by virtue of the basin's drainage of part of the state of Ohio, and yet the entire lower extent of the Beaver River is in the commonwealth of Pennsylvania. Four by-product coke plants in the basin are all located in Ohio. A number of dams have been built by the commonwealth of Pennsylvania and the Federal Government since 1933 to augment flows during low periods of runoff. This policy has proved to be successful through increase in the total oxygen available and decrease in the number of coliform organisms present. However, in one case, the increased velocity of flow between the point of pollution and a water works intake caused an increase of approximately 9,000 per 100 ml., in the coliform density of the raw water. The discharge of phenolic waste waters from the by-product coke plants has continued to produce intermittent objectionable taste and odor problems at the downstream Pennsylvania water works, principally during the cold months of the year. The installation of dephenolizing plants with dephenolized liquors used for coke quenching, as is done at the world's largest by-product plant at Clairton, Pa., may be the means of eliminating the objectionable condition at the water works.

The Allegheny River drainage basin is the largest in western Pennsylvania. Coal mining and steel production are the most important industries, considering the Allegheny basin as a whole. Other important industries are milk production and manufacturing, oil producing and refining, chemical industries, distilling, paper manufacturing and tanneries. Most of the mine drainage originating on the watershed is from the Kiskiminetas River basin which is a tributary to the Allegheny River. The Allegheny River upstream from the Kiskiminetas and the principal and most of the minor tributaries are alkaline. A sewage treatment program which has been carried on for some time, now is beginning to show results. From the industrial waste standpoint considerable treatment progress has been made. These plants include: the largest and most complete TNT plant waste treatment facilities in the country; complete treatment at a large whiskey distillery, where the raw waste load is the equivalent of 355,000 persons; complete treatment at a large cellulose acetate rayon plant; cyanide plating waste water treatment by chlorination; chromium removal facilities; more milk waste treatment plants than the rest of the state; oil separators; and acid neutralizing facilities. However, much remains to be done at small oil fields and refineries as well as at scattered, small industrial establishments. On one tributary to the Allegheny River, Mahoning Creek, a limited mine sealing policy has so reduced the acid content that sewage is becoming to be noticeable on low flows in the stream. This has resulted from the lack of the germicidal action of mineral acids and iron salts in mine drainage.

The problem of the lower Ohio is substantially the same as the Metropolitan Pittsburgh district, and steel with its related industrial production represents the major industrial development in this area. The discharge of acid mine drainage that reaches this portion of the Ohio River is principally from the Monongahela, Youghiogheny and Kiskiminetas rivers. Without the germicidal action of mine drainage there would undoubtedly be a serious pollution situation on this part of the river. Mine drainage is harmful in that it makes this part of the river less desirable for all uses and adds to the cost of the users of river water, whether it be for transportation, cooling or as a source of public water supply. It also has a marked effect on this part of the river by the "flush-outs" which occur during some low Ohio River flows. Flush-outs originating through rainfall from streams receiving heavy acid mine drainage loadings without corresponding runoff from alkaline drainage basins have resulted in an abrupt drop in the pH at Montgomery Island Dam, 30 miles below Pittsburgh, from 6.5 to an hourly low of 3.8. This phase of the mine drainage problem needs to be studied, as such a flush-out will be noted for miles down the Ohio River. From the industrial waste standpoint limited work has been done principally on taste- and odor-producing wastes. The three most important plants of this type are two dephenolizing plants for by-product coke plant waste waters, and waste treatment facilities, which are now being completed at the largest synthetic rubber plant in the United States. Further progress and controls in this part of the Ohio will be tied in with similar progress in the Pittsburgh area.

In summarizing the cleanup program in western Pennsylvania water supply improvement is of primary importance and precedence should be given first to those parts of the program that benefits the largest numbers of the public. A suggested order of importance is: (1) adequate treatment of sewage, (2) better controls over the discharge of taste and odor-producing waters, (3) better controls over the discharge of industrial wastes causing water treatment difficulties, (4) mine sealing, (5) flow augmentation with emphasis on those reservoirs best fitting into the pollution control program, and (6) the treatment of other industrial wastes. Certain of these activities should be carried out concurrently in order to secure the desired results. Flow augmentation is important to pollution corrections in this area as in most cases it contributes alkalinity to neutralize acids; dilutes the mine drainage discharged; smooths out slugs from acid mine drainage discharges or from unregulated industrial waste discharges; provides additional oxygenation during the critical stream flow period of the year, thereby increasing the assimilating capacity of the stream for organic wastes; limits temperature increases caused by large industrial users of the stream; and is of value for recreation, navigation and other purposes.

ROBERT P. LOWE

Stream Pollution in Southwestern Pennsylvania. BY L. S. MORGAN. *J. Amer. Water Wks. Assn.*, **38**, 713–716 (June, 1946).

The area covered by this paper is drained almost exclusively by the Ohio River watershed of which the main tributaries here are the Lower Allegheny River and its main tributary, the Kiskiminetas River, and the Monongahela River and its main tributary, the Youghiogheny River. A fairly dense population is present, and a large portion is located in communities stretching along the courses of the streams. Southwestern Pennsylvania is predominantly industrial in character and has been built up around the steel and coal industries, as the chief mineral source of the district is bituminous coal.

Stream pollution presently encountered can be naturally divided into three general classifications: (1) municipal sewage, (2) industrial waste produced by manufacturing establishments in processing and (3) drainage from bituminous coal mining.

Sewage pollution results from 180 public sewerage systems which have an estimated sewered population of 1,520,000 persons. There are 45 sewage treatment works now in existence which reduce the pollution load by an equivalent untreated sewered population of approximately 55,000. Therefore, the estimated equivalent sewered population as presently discharged in the entire area is approximately 1,465,000.

Industrial waste pollution is either organic (such as breweries, distilleries, paper mills, creameries, canneries, textile establishments and others) or mineral which is generally encountered in metallurgical mills. The total organic pollutional strength, in terms of sewered population equivalent, is not known for all industrial wastes. On the basis of an equivalent sewered population expressed in terms of 0.167 lb. of B.O.D. per capita per day, the known wastes have a pollutional strength of 860,000 persons, after allowance has been made for reduction in the pollution load in treatment works. Hence, the estimated equivalent sewered population in the southwestern Pennsylvania district, including sewage and industrial wastes as presently discharged, is approximately 2,325,000. From this figure 78.8 per cent is produced by Allegheny County (which includes the city of Pittsburgh) alone. Watershed distribution allocates 52.2 per cent to the Monongahela River, 33.6 per cent to be Allegheny River and 14.2 per cent to the Ohio River.

Acid wastes are discharged mainly from bituminous coal mines, but in addition to this source, there is an acid stream pollution load from pickle liquors and rinse waters from metallurgical industrial establishments. Acid mine waste data are based on the U. S. Public Health Service report entitled "Ohio River Pollution Survey, Final Report to the Ohio River Committee, Supplement C—Mine Drainage Studies," and includes all the acid mine drainage on the Ohio River watershed in Pennsylvania, except the Beaver River. Industrial wastes are included only for the territory in southwestern Pennsylvania. These combined loads, in tons of acid per day discharged, are as follows:

Watershed	Average Discharge Tons/Day
Kiskiminetas River	855
Allegheny River (except Kiski)	185
Youghiogheny River	540
Monongahela River (except the Youghiogheny)	500
Ohio River and minor tributaries (except the Beaver)	110
Total	2,190

Of this total amount, it is estimated that approximately 44 tons per day are acids discharged from metallurgical mills.

ROBERT P. LOWE

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Book Review

Handbook of Chemistry. By NORBERT ADOLPH LANGE. Handbook Publishers, Inc., Sandusky, Ohio. Sixth Edition, 1946. Price $7.00.

If it's a solid, gas or liquid, a practical working knowledge of its chemical and physical properties will be found in this compact handbook of 2,082 pages.

Although almost exactly of the same page content as the fifth edition, the sixth edition has been expanded to include additional chemical data and tables to take the place of the tables on pipes, valves and fittings and on flow of water and gas in pipes that were a part of the fifth edition. Revisions have also been made in 274 pages of standing matter from previous editions. The author suggests that the most important change in the new edition is the revised and enlarged table on physical constants of inorganic compounds, which now includes 2,603 compounds. A similar table containing information on 6,507 organic compounds is prefaced by a glossary of organic chemistry nomenclature and a complete formula index.

The pages dealing with industrial and municipal water supplies include a summary of the USPHS Drinking Water Standards as adopted in 1942. It is unfortunate that the new standards adopted in February, 1946, were not reported here to bring this section of the book entirely up-to-date.

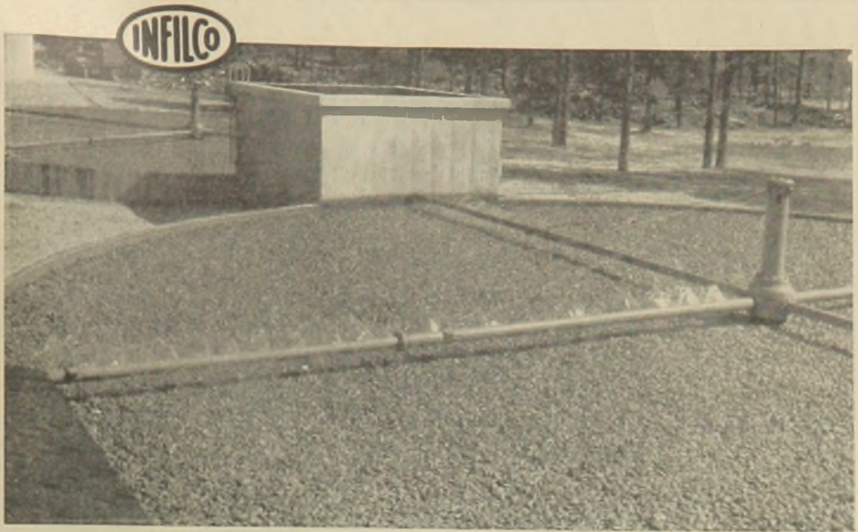
A 271-page appendix of mathematical tables and formulas is also contained in the book.

Lange's handbook will be a useful general reference for sewage works superintendents and chemists. The text and tabular material on first aid, antidotes for poisons and pertaining to hazardous chemicals, flammable substances, etc., will immediately attract the interest of this group. Sanitary engineers concerned with stream pollution abatement and wastes disposal works will also find the book to be a useful library item. The increasing interest in industrial wastes treatment and disposal entails greater emphasis on the chemistry of industrial processes and of the wastes issuing from them; the Lange handbook is particularly strong in its coverage of the complex organic compounds that may be encountered in such wastes.

Bound in serviceable fabricoid, of good typography and format, and thoroughly indexed for quick and convenient reference, Lange's handbook should find a place on the bookshelves of many sewage works technicians.

W. H. WISELY

Original Woodcut by Lynd Ward



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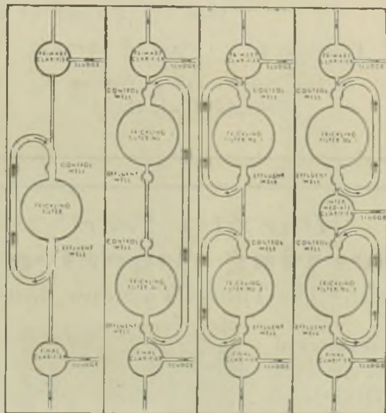

Fig. 1 Fig. 2 Fig. 3 Fig. 4

Fig. 1—Single-stage plant with direct recirculation.

Fig. 2—Two-stage plant with direct recirculation to primary filter.

Fig. 3—Two-stage plant with direct recirculation within each stage.

Fig. 4—Two-stage plant with direct recirculation within each stage and with clarification between stages.

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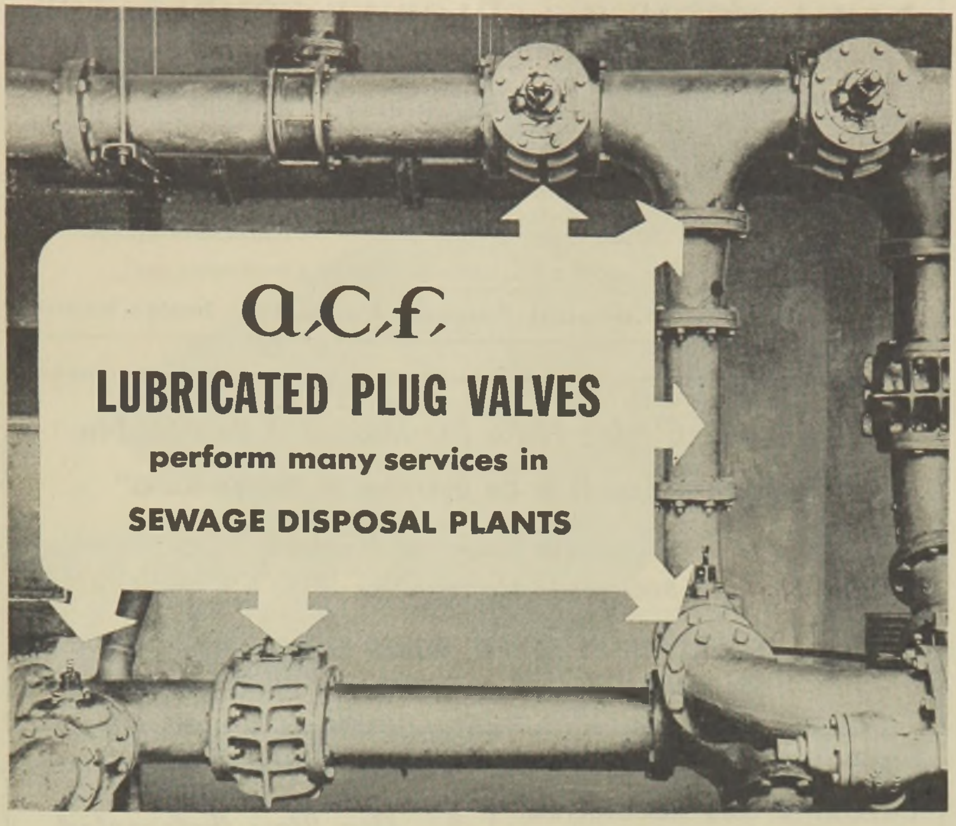

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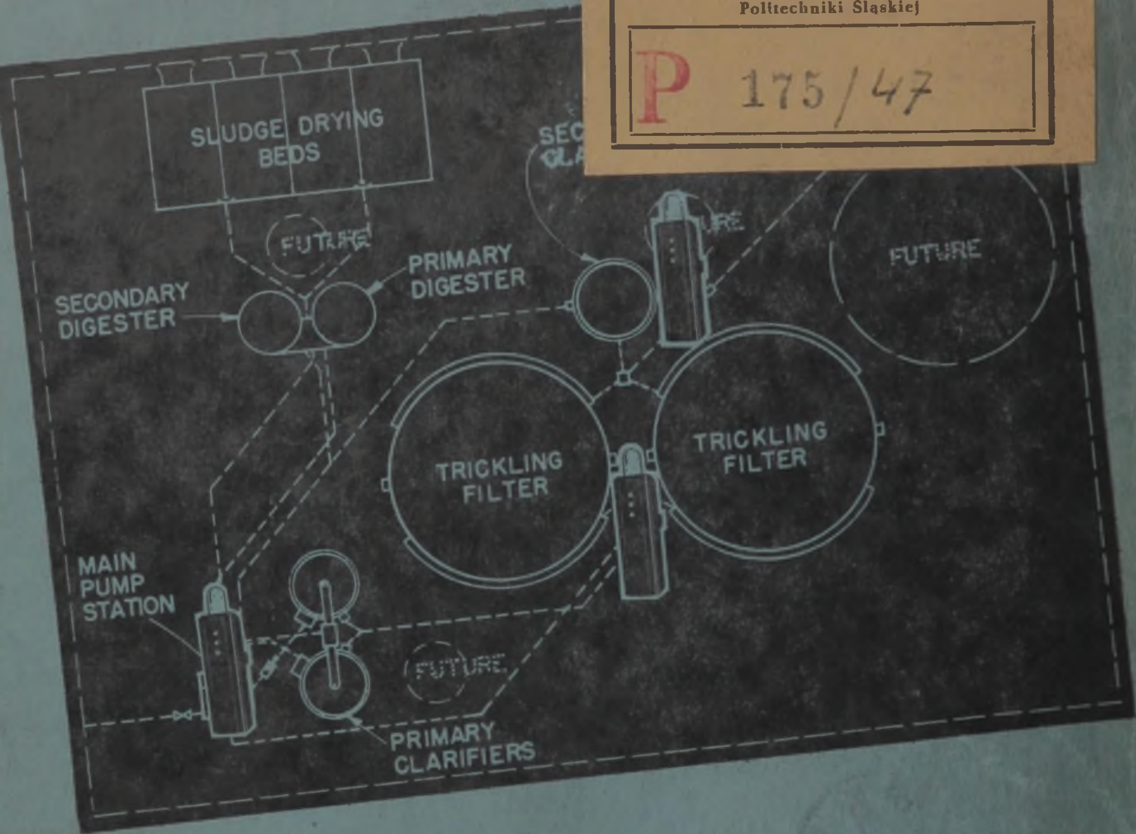

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