SEWAGE WORKS JOURNAL

ANNUAL CONVENTION NUMBER

VOL. XIII SEPTEMBER, 1941 NO. 5

Special Features

Twelve Papers on Plant Operation

The Operator's Corner

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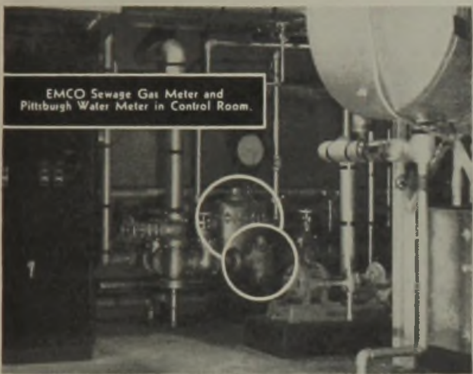

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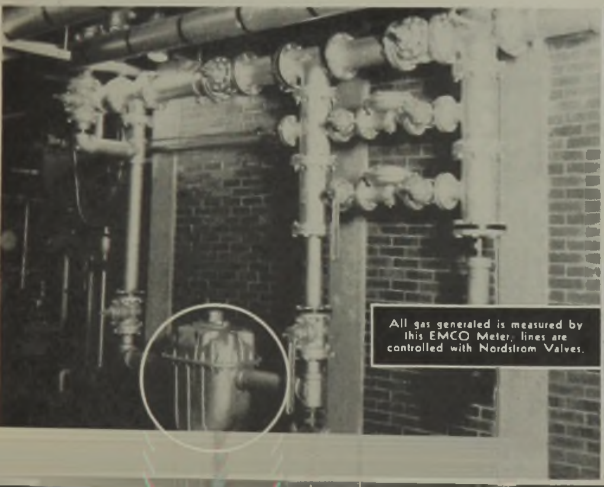

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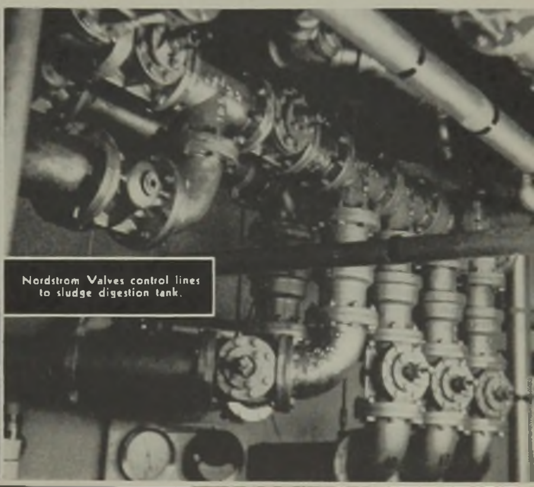

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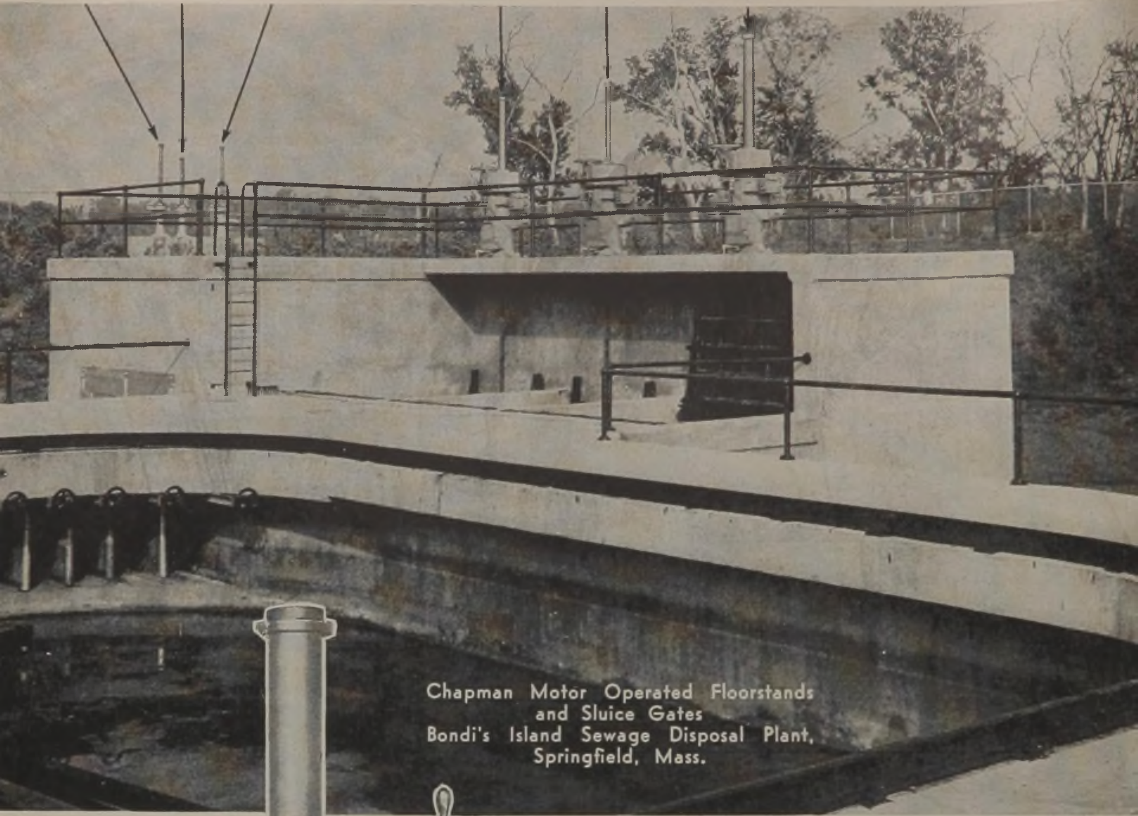

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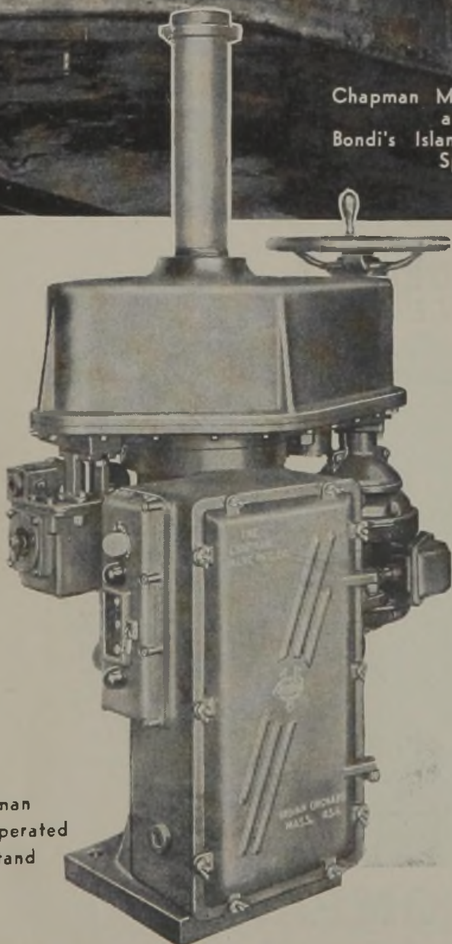

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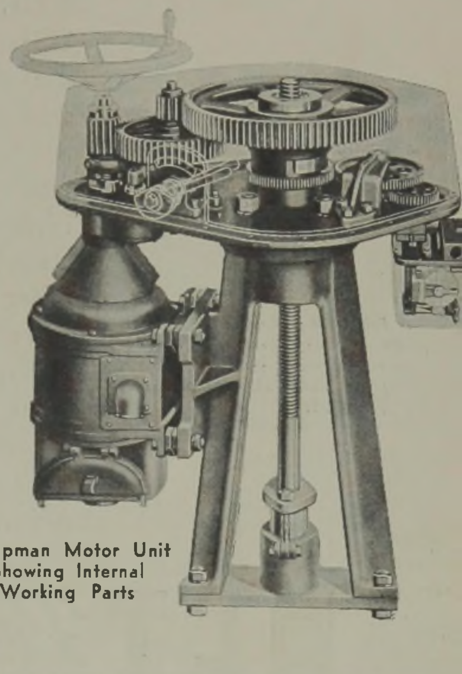

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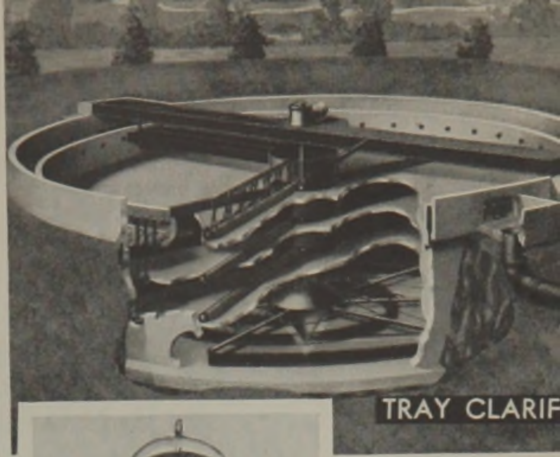
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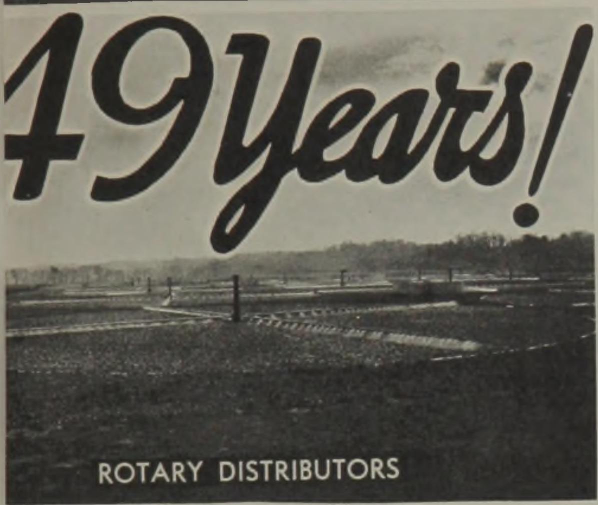
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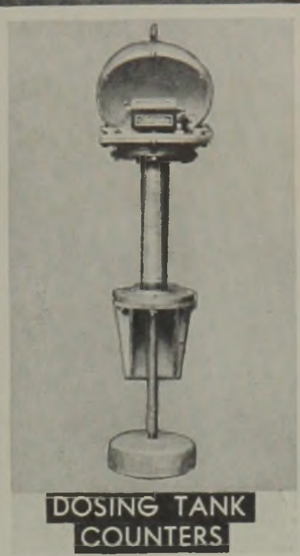
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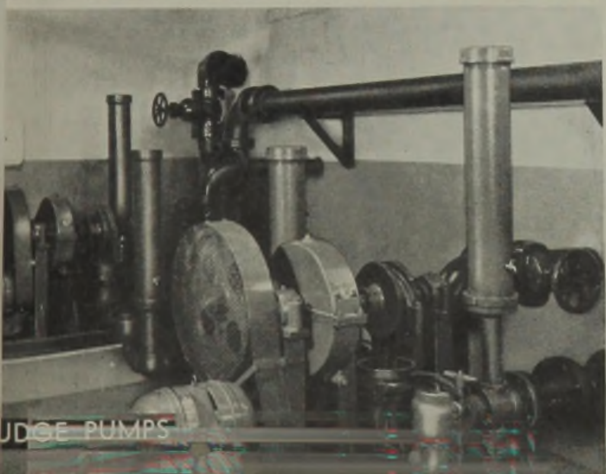
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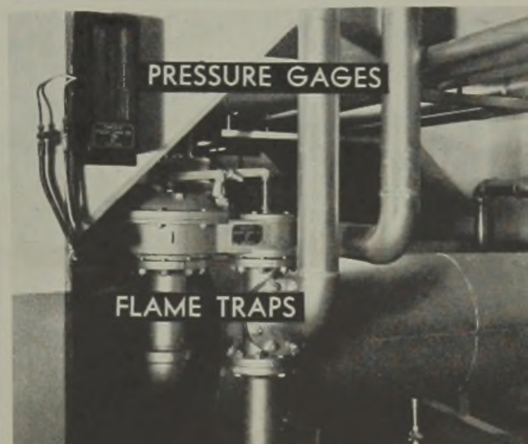
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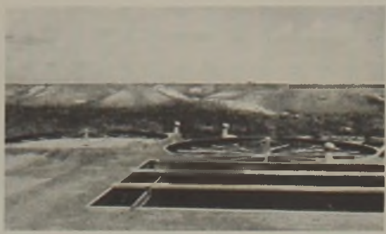

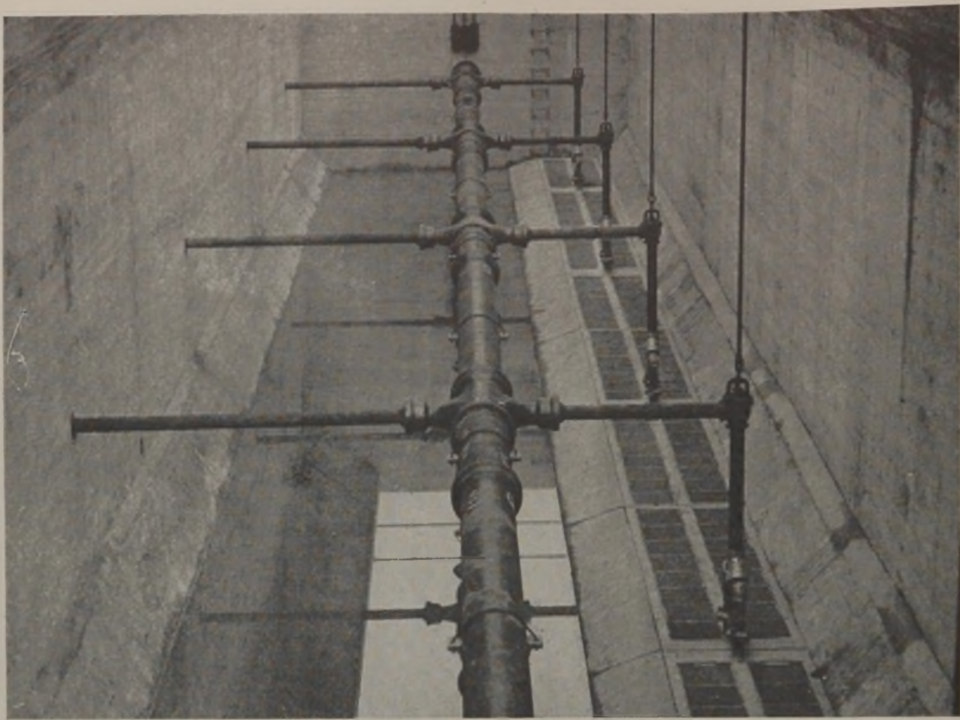

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Plant Operation

ALUM TREATMENT OF DIGESTED SLUDGE TO HASTEN DEWATERING

By Walter A. Sperry

Superintendent, Aurora Sanitary District, Aurora, Ill.

The following comments on the use of alum and other agents as an aid in hastening the dewatering of sludge on sand beds is offered with some apology. As early as 1923 John R. Downes [1] of Plainfield, New Jersey, effectively demonstrated that alum materially hastened the dewatering and drying of sludge. Since 1936 Toronto has used alum effectively as a dewatering agent. Numerous published references have been made to alum and its use has been a regular practice in a number of local sections. In many ways, however, the application of alum is a "rediscovery." There are still many operators, particularly in the plants built in recent years, who could use alum effectively if the process were known to them. Moreover, most articles mention such use but give few details. The most recent discussion is given by Gordon J. Wiest of Lancaster, Pennsylvania.[2, 3]

In the latter part of 1939 the Aurora Sanitary District was faced with a difficult situation due to shortage of drying space, full digesters and the approach of winter. Alum proved an effective aid. Many details of our experiments and experiences are herein recorded in the hopes that the discussion given will be helpful to others.

Alum.—A typical commercial alum, similar to that used as a coagulant in water works practice, has the approximate formula—$Al_2(SO_4)_3$ $14\,H_2O$. It contains 49.4 per cent equivalent sulfuric acid. It is granular in form, readily soluble, usually comes in one hundred pound bags, requires only a dry place for storage and can be kept indefinitely without deterioration. It can be purchased in minimum car-load lots (20 tons) for approximately $21.50 per ton, f.o.b. works. It is generally available almost anywhere in the country.

A general survey of published articles indicates general agreement that the effectiveness of alum appears to be due to its acid content rather than to the coagulating power of its aluminum oxide ($Al_2\,O_3$) content. The inter-action between the acid of the alum and the abundant carbonate salts dissolved in sludge liquor releases a considerable volume of carbon dioxide gas, which tends to free and float the sludge particles to the top of its carriage water. Any colloid properties of the sludge appear to be effectively destroyed. If one examines a bed of alum-treated sludge shortly after its withdrawal it presents to the eye the typical wrinkled, lumpy surface, clearly indicated in Fig. 1–*A*. It is entirely unlike the smooth, glass-like, watery surface of an untreated bed as shown in Fig. 1–*B*. Moreover, if one plunges a hand through such a bed there is found a floating mass of concentrated sludge over a thin supernatant-like body of water. Within twenty-four hours an alum treated bed of 12-in. depth will easily drain to 6 or 7 in. in depth,

Fig. 1–*A*.—Appearance of alum treated sludge bed showing the typical "wrinkled" lumpy surface produced.

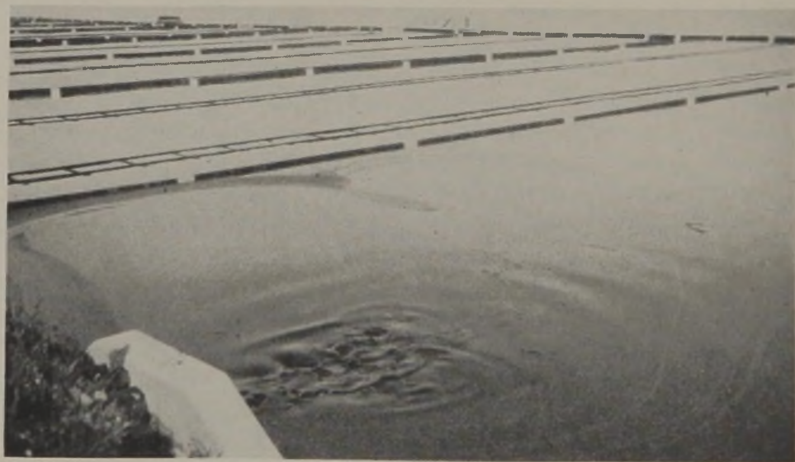


Fig. 1–*B*. Appearance of an untreated sludge bed showing the smooth watery surface produced.

whereas, an untreated bed will not drain out more than 2 inches. We have seen beds so treated break from under the side-boards and run clear water for a considerable period.

Further evidence of the disappearance of the colloidal nature of the sludge is indicated in Figs. 2 and 3. The left bed in Fig. 2 was drawn without alum application on November 3, 1939. The right bed was drawn November 8—5 days later—and with alum treatment. On November 10 there was 0.55 in. of rainfall. Figure 2 pictures these beds on Sunday morning, November 12, showing water still "pooled" in the untreated bed. Figure 3 shows these same beds on November 13. Bed 7 shows good "cracking" started with no cracks yet in Bed 6. This phenomenon has been observed repeatedly.

Aurora sludge would be generally described as a well digested sludge of 47.4 per cent volatile matter and 6.9 per cent total solids content. It is a combined primary-secondary sludge from two-stage digestion. The Aurora drying beds are 40 by 125 ft. in area. Sludge is

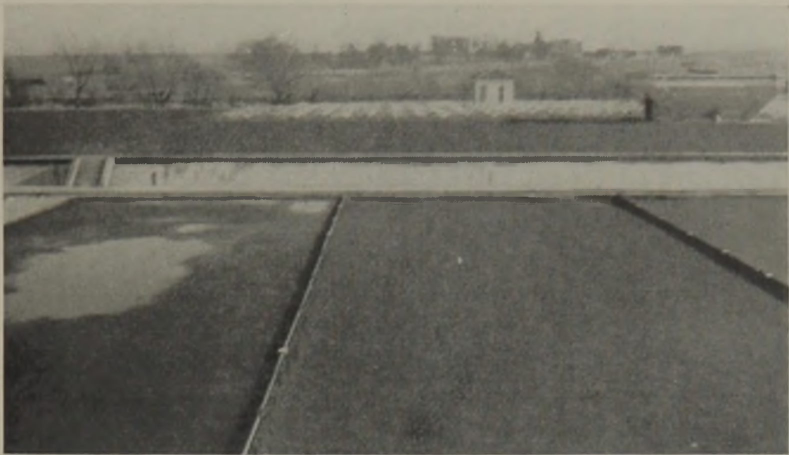


FIG. 2.—Contrasted sludge beds. Bed No. 6 at left untreated. Bed No. 7 at right alum treated.

usually drawn to a depth of 1 ft., which gives a volume of 5,000 cubic feet. Alum is applied normally at 400 lb. per bed, which gives the following equivalents:

At the rate of:

1 lb. of alum to 12.5 cu. ft.
1 lb. of alum to 93 gal.
2.2 lb. of alum to 1.0 cu. yd.
1.25 gm. of alum to 1.0 liter.

These quantities represent average practice.

It is difficult to give more than an approximate statement, based on Aurora's experience, of the drying days saved by the use of alum, partly due to the interruption by rain, partly to the fact that the beds must be frozen during the winter time for removal of sludge and partly to the practice of not using alum through the mid-summer period. The indications, however, are that alum-treated beds, if not too much rained on, could be cleaned in 12 to 15 days as against 20 to 25 days for untreated beds, with equally favorable weather conditions. Experience definitely indicates that sludge on alum-treated beds is not delayed in removal nearly so much by rain as sludge on untreated beds.

Due to bulking induced by secondary sludge, Aurora sludge may be as thin as 5 per cent total solids content and rarely exceeds 8 per cent.

It has been necessary to discharge sludge at approximately 40 to 50-day intervals, which forces winter cleaning. Under this condition the beds must freeze solid in order to remove them by prying the cake loose, breaking with picks and removing in chunks. It was the forced emergency of full beds and full digesters in the latter part of 1939 that first caused the use of alum. The use of alum, however, proved a surprisingly economic aid since the dewatering effects tend to reduce the thickness of the cake to be frozen from one-third to one-half. As a result

FIG. 3.—Shows the same sludge beds as in Fig. 2. Bed No. 7 left alum treated. Bed No. 6 at right no alum.

of this, winter cleans in 1938 that required 27 days to accomplish at a cost of $800 with no alum was reduced to 11 or 12 days in January, 1939, at a cost of about $500 for hired labor. This experience was repeated in the winter of 1940–41.

Sulfuric Acid.—On the theory that sulfuric acid is the active agent in alum a few laboratory experiments were run at Aurora using sulfuric acid. These isolated tests showed results equivalent to alum, but all formal experiments using a range of acid application gave negative results. It has been used successfully, however, eleswhere.

Herbert O. Johnson, Superintendent, Belgrave Sewer District, Great Neck, New York, writes the following interesting paragraph in a letter dated February 3, 1941. "Your experience using alum for accelerating the drying of digested sludge was of great interest since it paralleled similar work at this plant. It might interest you to know that we are using commercial 95 per cent sulfuric acid as a coagulant with, I think, better results than with equal quantities of alum. Our rate of application is approximately double yours. We feed 4 lb. per wet ton of sludge applied to the beds. Minimum drying time was 5 days for an application in June. Solid content was 24 per cent (after dewatering). Average drying time over the summer months was 8 to 12 days. The use of chemicals to assist in sludge drying is of great advantage to us since it permitted us to postpone the construction of further sludge drying facilities."

Four pounds of 95 per cent sulfuric acid per ton of sludge is equivalent to 600 lb. of acid per 5,000 cu. ft. bed (average Aurora bed), or three times Aurora's alum application, since 400 lb. of alum is equivalent to about 200 lb. of sulfuric acid. It might be pointed out, however, that the difficulty of shipping and handling the acid and the possibility of serious accidents to the men are considerations in comparing the direct use of acid with alum. The cost of acid per ton is considerably more than alum per ton. 66° Beaumé acid containing 93.2 per cent sulfuric acid is quoted at approximately $35.00 per ton, f.o.b. works, in carboys.

Iron Salts.—Most articles refer to iron salts as being as effective as alum in the dewatering of digested sludges. Laboratory experiments at Aurora indicated the ferric iron salts to be generally equivalent to alum and quite as effective as dewatering agents. Some characteristics of iron salts are here given.

Ferric Chloride...........	$Fe_2Cl_6\ 6H_2O$	25.8% Iron	50.6% HCL
Ferric Sulfate.............	$Fe_2(SO_4)_3\ 9H_2O$	20.0% Iron	52.4% H_2SO_4
Ferric Nitrate............	$Fe_2(NO_3)_6\ 9H_2O$	30.0% Iron	28.7% HNO_3
Ferrous Sulfate...........	$FeSO_4\ 7H_2O$	20.0% Iron	35.3% H_2SO_4

Experiment 12 using ferric sulfate gave the following results.

% Total Solids in Sludge	Dosage, Grams per Liter	Water Discharged After 24 Hours, Liters per Cu. Ft.	% Total Solids in Sludge After 24 Hours
5.9	Control	4.5	9.2
	1.5	9.8	10.1
	2.0	10.4	10.5
	2.5	11.7	10.2
	3.0	12.7	15.4
	3.5	13.2	14.2

In experiments 11 and 13 ferric chloride was applied to a 5.2 per cent sludge and ferric nitrate to a 4.9 per cent sludge. The results were identical with those given for Experiment 12, above, except that the nitrate salt was less efficient.

The ferrous iron salts, on the other hand, were of no value.

Experiment 8 using ferrous sulfate gave the following results.

% Total Solids in Sludge	Dosage, Grams per Liter	Water Discharged After 24 Hours, Liters per Cu. Ft.	% Total Solids in Sludge After 24 Hours
5.5	Control	5.8	7.3
	1.5	6.6	6.8
	2.0	6.4	7.0
	2.5	6.2	7.1
	3.0	6.2	7.2
	3.5	6.4	7.5

Despite the fact that the acid content is believed to be the effective agent, ferrous sulfate after several trials showed no advantage, even though the acid content of the larger dose was more than equivalent to the acid in the effective alum dose. There is no explanation for this except that the inter-structures of the ferric molecule versus the ferrous molecule may account for it.

In general, despite the effectiveness of the ferric iron salts, they are more expensive than alum and more difficult to store and handle.

These objections are more than outweighed by the danger of using iron salts due to their tendency, in time, to completely plug the sand bed with oxidized iron. The filtrate from the alum treatment was always clear whereas the effluent from iron salts was always colored with ferrous iron. The cloth tied over the mouths of the fruit jars used for filters, after two or three iron experiments, became plugged with oxidized iron and had to be scraped free or renewed. This is sufficient warning that the use of iron as a reagent on sludge beds could prove disastrous.

Carbon.—In some places activated carbon has been used with some success. Gordon J. Wiest, Chemist, Lancaster, Pennsylvania, has described his experience with activated carbon.[2] T. R. Haseltine, Superintendent, Butler and Grove City, Pennsylvania, plants, writes the following interesting paragraph in a letter dated September 16, 1940, relative to the use of activated carbon:

> You will be interested to know that the activated carbon has worked out quite satisfactorily at Grove City as an aid to sludge drying. Our sludge at that plant contains only 3 to 4 per cent solids and is high in organic matter. It is quite similar to the Lancaster sludge with which Wiest experimented. From what I have been able to find out about carbon, its principal advantage, when used in a digester, is that it aids the separation of the solids from the liquor, thus producing a clearer supernatant. It probably does the same thing when applied to the sludge run onto the drying beds. With a very thin, watery sludge, such as prevails at Lancaster or Grove City, this would facilitate drainage and, hence, drying. With a heavier sludge, such as you have at Aurora, there would probably be very little benefit from carbon.

All experimental attempts to get effective results from activated carbon at Aurora failed, regardless of the quantity used.

It has always been the feeling of the writer that activated carbon was mis-applied in sewage treatment processes, both by reason of the nature of the reagent, as well as its cost.

Experimental.—The first use of alum on the Aurora beds in the latter part of 1939 and the forepart of 1940 proved so interesting that it was determined to make a more extensive study of alum and other agents in the laboratory. These experiments extended from the forepart of April to the middle of May, and to the number of thirty, or more. In most cases experiments were repeated to confirm results, and the few examples given here are typical of the general run.

The apparatus designed for this work consisted of a battery of half-gallon fruit jars, from which the tops were snapped off. A piece of muslin was tied over the mouth of the jar, and on this was placed a layer of about three-quarters inch of coarse sand, which approximated sludge bed conditions. This was a great improvement over the method of applying alum to sludge in cylinders or cones since there was no way of measuring the water released. Figure 4 shows the typical arrangement of the apparatus. Fifteen hundred cc. samples were treated in every case and the number of jars permitted a "control," and a reagent application running from below average treatment to well above. Figure 4, Experiment 5, shows a typical double set-up using a 9 per cent sludge and a 6.5 per cent sludge. The following table indicates the results:

% Total Solids in Sludge	Dosage, Grams per Liter	Water Discharged After 24 Hours, Liters per Cu. Ft.	% Total Solids in Sludge After 24 Hours
9.0	Control	1.9	9.6
	1.5	2.4	9.3
	2.0	4.4	10.5
6.5	Control	4.2	8.6
	1.5	9.4	9.9
	2.0	11.9	12.4

Figure 5, Experiment 16, illustrates what happens when alum is applied to a very thin sludge. The results of Experiment 16 (Fig. 5) are here given:

% Total Solids in Sludge	Dosage, Grams per Liter	Water Discharged After 24 Hours, Liters per Cu. Ft.	% Total Solids in Sludge After 24 Hours
2.7	Control	11.3	4.4
	0.5	21.0	—
	0.75	21.2	14.3
	1.0	21.2	—
	1.5	21.2	16.4
	2.0	21.4	—

The data shown above were confirmed by repeated experiments.

Figure 6 illustrates the method of bed application. This appears to be important. Two hundred pounds of granular alum is quickly soluble in a barrel of water. It was found best to partially fill the barrel with water, add the 200 lb. of alum directly, and then complete the filling. After standing a few minutes (10 to 15) with stirring, solution is completed. In our case a pitcher pump was mounted on a board, allowing the alum to be pumped into a large tin funnel and a length of 1-in. hose. The hose terminated, as shown, at the back end of a section of furnace pipe, not to exceed 24 in. long, which was thrust into the end of the sludge discharge pipe. A little practice readily enabled the operators to pump at approximately the rate of discharge so that the application of 400 lb. of alum would be equally distributed to the discharging sludge. This method gave uniform distribution and avoided all the difficulties of clogging orifices from sticks and dirt and receding "heads" where a spigot or orifice is placed near the bottom of a barrel. The mixing through the short piece of pipe and the subsequent mixing

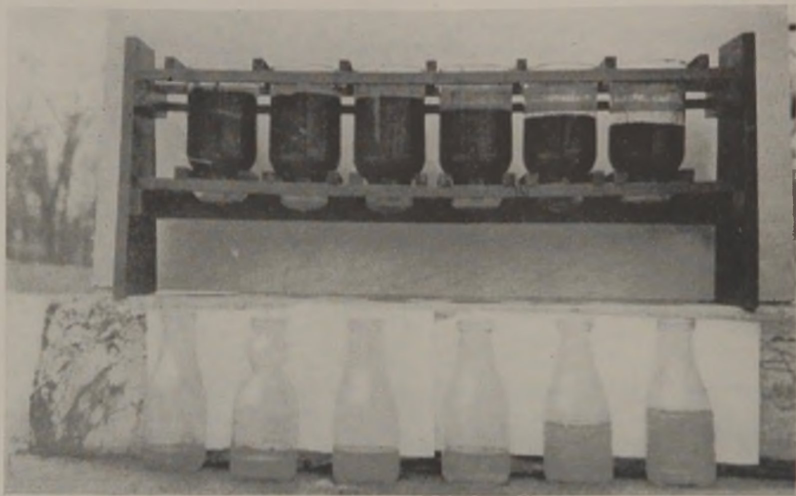


FIG. 4.—Shows typical set up of apparatus devised to make alum studies on sludge. Experiment No. 5 compares effect of alum on a 9.0 per cent T.S. sludge and a 6.5 per cent T.S. sludge.

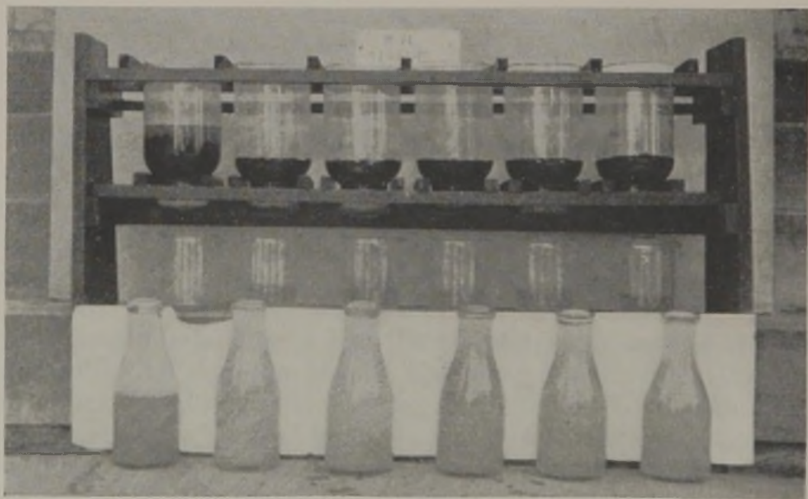


FIG. 5.—Experiment No. 16 showing effects of alum on a 2.7 per cent T.S. sludge.

of the stream discharging to the bed is sufficient. Alum fails to work if too much mixing is provided. This was amply illustrated in the laboratory. Considerable care was necessary in apply the alum to the fruit jars. If a minimum number of lapping strokes of a stirring rod were not used the experiment failed due to over mixing. This fact is strikingly illustrated in the following paragraph quoted from John R. Downes's original article [1] published in July, 1923.

Fig. 6.—Shows the general method of applying alum to sludge beds as described in the text.

Every chemist considers thorough mixing of reagents almost essential to every reaction and the water chemist, familiar with the use of alum in treating water, knows the value of prompt and vigorous agitation in obtaining results. It is not strange, therefore, that those who have sought to treat sludge with alum have sought to obtain thorough mixing by means of agitation. The investigation at Plainfield was proceeding along these lines with somewhat indifferent though promising success, when the Superintendent suggested that his long experience with sludges led him to believe that the violent agitation was undoing the work of the alum and even destroying the original tendency of the sludge to become drainable. Mixing was gradually cut down to what was considered a minimum with constantly improving results. After the supposed minimum had been reached the accidental misplacing of a barrel by a laborer led to a further cut in agitation with great improvement in results and a cutting of the amount of alum required to a negligible quantity. Finally, a stream of alum solution (100 lb. to 50 gal. of water) was allowed to run into the stream of flowing sludge just as the sludge left its channel to enter the drying bed. The reaction was completed in the bed itself, in comparative quiescence. The sludge instantly congealed to a lava-like consistency and free water ran out at the edges in the course of about twenty minutes.

The following pertinent paragraph discussing when to use alum is taken from the same article:

To determine whether or not a sludge requires alum to assist in dewatering, take a sizeable sample in a glass jar. If clear liquid separates out at the exact bottom of the container, alum will probably be of little assistance. If, however, the liquid is murky or separates out at any point other than at the bottom, there is every reason to believe that alum will be beneficial.

Two practical observations should be included in this discussion. Both have to do with the design of the sludge bed. First, the sand used should be coarse. There should be an entire absence of fine-mesh sand. It should be made up of anything from 40-mesh sand to fine torpedo sand. The writer knows of instances where bed sand was composed mostly of 60, 70 and 80-mesh sand and this further rendered impervious by clay so that alum experiments failed, not by reason of its dewatering effect but rather due to the impervious nature of the underlying bed. The water release is immediate and the efficiency of alum is in direct ratio to the ability of the sand to drain the water off. The second is a corollary of the first. The drainage tile underneath should be of ample size to carry off the water as fast as released.

Three curves accompany this article to summarize the general results of all the experiments, to illustrate the benefits derived from the use of alum, and to show some of the limitations to its use.

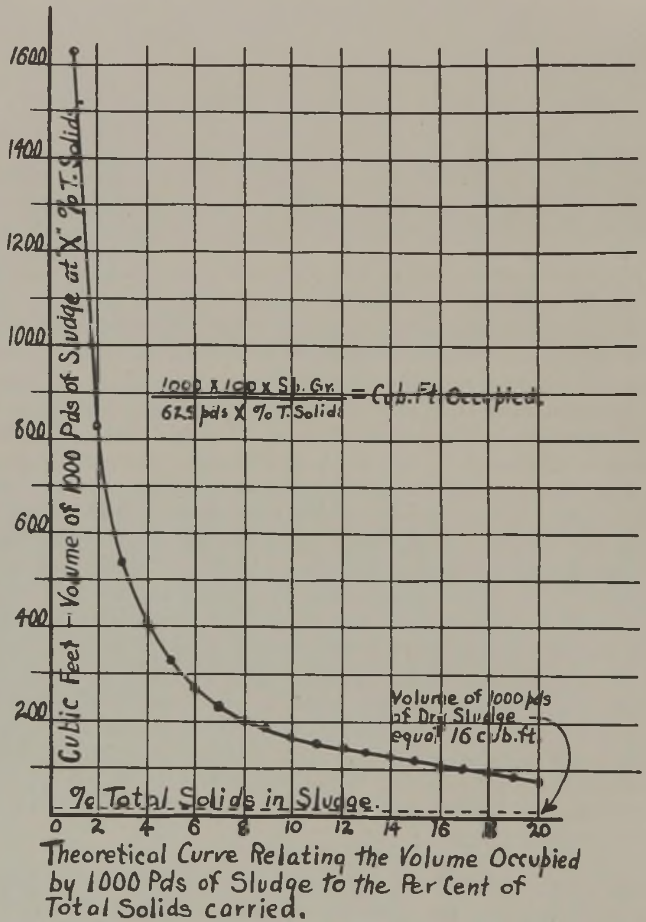


FIG. 7.—Curve showing the theoretical water to solids relation in a sludge mixture.

Figure 7 presents a fundamental, theoretical curve relating the volume of water to the volume of sludge at various per cent total solids content. In a number of instances alum has been reported as a failure. On inquiry it was found that it was used on a 9 per cent total solids sludge. An examination of Figure 7 indicated the reason. In all cases tests of total solids of the dewatered sludge in the experiments gave from about 9 to 14 or 15 per cent as the limiting total solids content of the dewatered sludge after twenty-four hours. It is obvious, therefore, that the application of alum to a 8 or 9 per cent sludge would have little effect and increasingly less for heavier sludges. This is confirmed by the data given in connection with Figure 4, Experiment 5. Conversely, a very thin sludge requires but little alum for the reverse reason, as indicated in the data accompanying Fig. 5, Experiment 16. Alum, therefore, is most effective when used on sludges whose total solids content runs below 8 or 9 per cent. At certain plants, however, where the sludge to the beds carries as high as 12 per cent total solids, alum has been reported as still showing some benefit. No 12 per cent total solids sludge was available at Aurora.

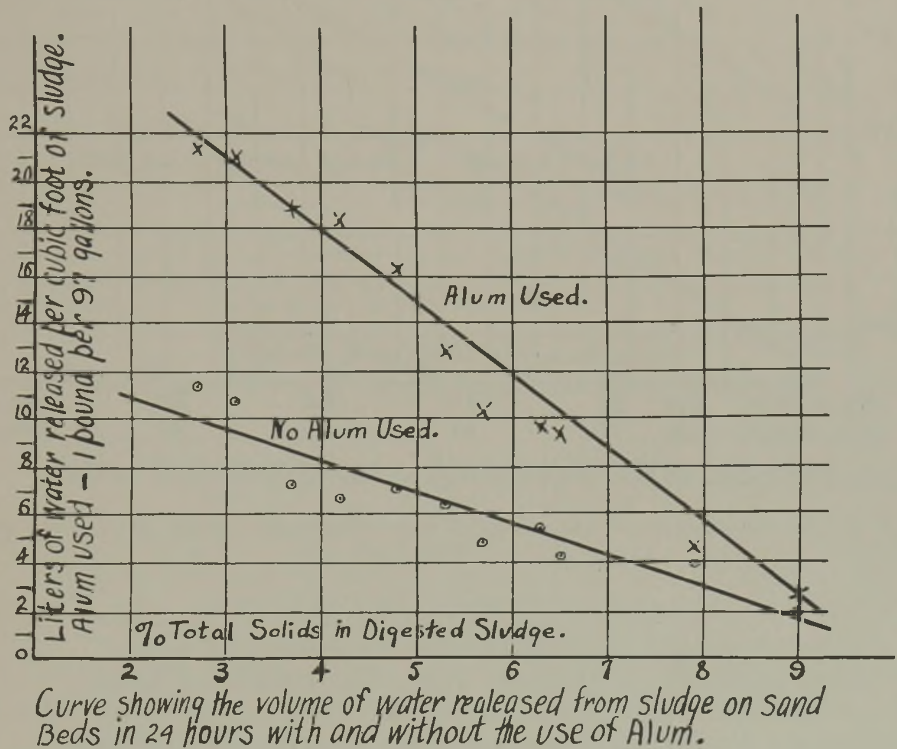


FIG. 8.—Compares the water released from sludges on a drying bed with and without the application of alum.

Figure 8 is an important summary of the whole range of experiments in primarily indicating the limitations for the use of alum as terminating, for the most part, at 9 per cent. It also shows the diminishing effectiveness of alum versus no alum for a range of sludges from 2.5 to 9 per cent total solids content.

Figure 9 again summarizes the range of experiments. The chief point of interest on the curve is the 2.7 per cent sludge. Here a dosage of 0.5 grams per liter is as effective as 2 grams; whereas for a 4.9 and 6.4 per cent sludge the dewatering effect is in proportion to the amount of alum used, as is the cost. It is quite likely, therefore, that for sludges with less than 3 per cent solids content alum might not be used at all. If used, much smaller amounts would be sufficient. For sludges approaching 9 per cent and above, alum is of less value.

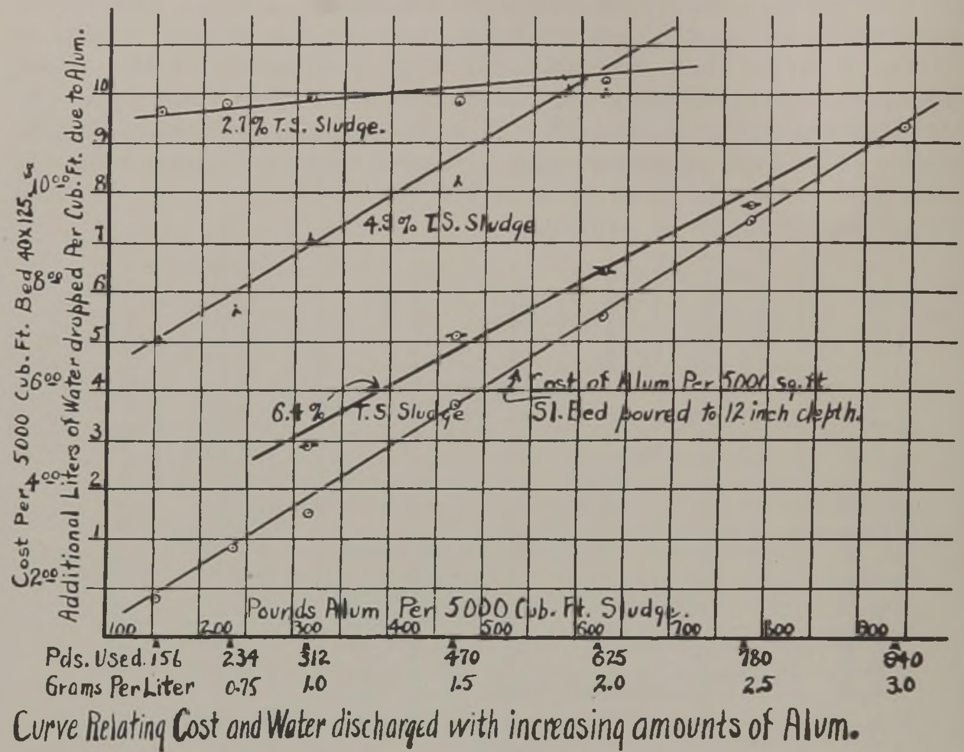


FIG. 9.—Curve to compare cost and amount of water released from sludge by increasing alum doses.

General Summary and Conclusions

Alum appears to be the most effective dewatering agent.

Alum appears to be the most economical dewatering agent.

All trivalent (ic) iron salts are effective dewatering agents. Ferric sulfate and ferric chloride are more effective than ferric nitrate.

Di-valent (ous) iron salts produce no dewatering effects.

Despite the effectiveness of ferric salts, they should not be used, since they tend to deliver ferrous iron to the underdrains, which would quickly clog the sand with iron oxides.

Sulfuric acid is reported as effective as alum at some plants.

Activated carbon has also been reported effective in some plants, but proved ineffective on Aurora sludge.

Alum is most effective on sludge with a total solids content under 9 per cent.

On sludges under 3 per cent, small amounts of alum, *i.e.* 1 lb. to 200 to 300 gallons is as effective as 1 lb. to 70 to 90 gallons.

The maximum effect of alum to dewater sludge is in the first twenty-four hours.

Alum-treated sludges are much less affected by rain, after the discharge, than are sludges not so treated.

Where alum is to be regularly used for dewatering sludges there should be an ample drainage tile provided and the sand used should be definitely coarse.

Greenhouse experiments indicated that there was no adverse effect on plant life where alum was used for dewatering purposes.

There is evidence to indicate that alum may not be equally effective as a dewatering agent on the sludge from some plants. This indicates the wisdom of local pilot work for trial purposes.

Alum is especially valuable as insurance against unexpected weather conditions when applied to spring, fall or winter drawings.

Due to its rapid dewatering effect, alum saved its cost at Aurora when applied to winter-drawn sludges.

References

1. John R. Downes, "Expediting Drying of Sewage Sludge," *Public Works*, July, 1923.
2. Gordon J. Wiest, "Activated Carbon Aids Sludge Drying," *Municipal Sanitation*, 2, 140 (March, 1940).
3. Gordon J. Wiest, "Some Considerations to the Question of Sludge Density," *Waterworks and Sewerage*, 216 (May, 1940).
4. C. E. Keefer, *Sewage Treatment Works*, 422–423.
5. C. C. Agar, "Chemical Treatment of Sludges to Facilitate Disposal," *This Journal*, 270 (March, 1933).
6. Willem Rudolfs and E. J. Cleary, "Sludge Disposal and Future Trends," *This Journal*, 409 (May, 1933).
7. Willem Rudolfs, *This Journal* (July, 1929).
8. *Sewage Works Engineering*, Question Box, 230 (April, 1941).

FILTRATION OF SEWAGE SLUDGE AT NEENAH–MENASHA, WISCONSIN *

By Jess M. Holderby

Superintendent, Sewage Treatment Works, Neenah-Menasha, Wis.

Vacuum filtration has, in the last six or seven years, definitely come to the front as a practical means of dewatering sludge. Prior to about 1935 there were very few sewage works using vacuum filters as part of their routine operation. Since then however, installations have been made far and wide until at present there are undoubtedly well over a hundred plants employing the filter and there are probably more than twice that number of individual units installed singly and in multiple.

The advisability of employing vacuum filters in any given case is a subject so tied up with local considerations that it would be sheer folly to attempt any blanket conclusions. All that can possibly be justified in a general discussion such as this is to point out the advantages and disadvantages, outline the application, describe the process briefly and perhaps present observations and results from the writer's own experience.

Vacuum Filters or Sand Beds?

As compared to drying sludge on sand beds, as is commonly practiced at the majority of sewage plants, vacuum filtration has a number of outstanding points in its favor. Space requirements are infinitely less, weather which would prevent drying on beds has no effect on filters; digestion space may be cut down even, in some cases, to the vanishing point; and last but not least, plants employing vacuum filters can safely be located near or even in built-up areas without danger of justifiable nuisance complaint.

On the other side of the argument it can be pointed out that the use of filters with their auxiliary equipment makes a relatively complicated mechanical process out of one which has traditionally been a model of mechanical simplicity, and that the necessity of conditioning sludge before filtration calls for certain technical control which, it is admitted, the proverbial "one armed" operator might find troublesome. Obviously Mother Nature and Old Sol cannot be "fired," nor can the operations of simple gravity be circumvented, without encountering some previously non-existent problems. However, successful and economical installations of vacuum filters are to be found in small one-man plants, in intermediate size plants and in large metropolitan plants. In the final analysis, therefore, it may be reiterated that the choice between filters and sand beds depends entirely on local conditions.

*Presented at the Wisconsin Sewage Works Operators' Conference, Sheboygan, Wis., May 20, 1941.

Application of Vacuum Filters

Present day practice in sewage treatment gives rise to many different types of sludge, practically all of which have, on large or small scale, been successfully handled by vacuum filters. Although it was early held that the process was applicable only to digested or activated sludge of relatively low solids content, experience has proved that raw sludge of almost any variety and of almost any concentration can be dewatered by means of the filter. Seldom, however, can a sludge be filtered economically in the state in which it is produced and accordingly it is customary to precede filtration with one or more conditioning steps.

The first step, one which may or may not be employed, is that of digestion. Digestion, if complete, will usually reduce by 30 to 40 per cent the weight of solids to be dewatered and may in some cases be justified by this consideration alone. If the dewatered solids are to be finally disposed of in such manner as to be potentially hazardous to health, as for instance when used as fertilizer, it may be necessary to digest prior to filtration in order to destroy the pathogenic bacteria and to decrease the putresability of the organic matter. Again, certain sludges filter better, giving larger yields and dryer cakes when at least partial digestion is accomplished. As stated by Jones (*This Journal*, **12**, pages 1106–1113), "Whether or not to digest is still an open question in which controlling factors such as location of works, size of installation, type of sludge, storage of wet sludge, control of nuisance, decrease in weight of solids to be filtered, temperatures, grease content, concentration of solids, utilization of gas, disposal of the filter cake and cost both capital and operating must be taken into consideration." Actually more installations filter digested sludge than otherwise.

The second step usually necessary is that of concentrating the sludge. As it comes from the clarifier the consistency of sludge is too variable for good filter operation. To render the sludge more nearly uniform and to decrease somewhat the amount of water the filters must handle, some means are usually provided to store the fresh material for a short time, provisions being made for drawing off excess water which may separate in storage. In some plants this is accomplished by means of a batch process employing simple hopper bottomed tanks to which fresh sludge is pumped and from which concentrated sludge is drawn; the tanks being operated so that at no time is sludge being simultaneously pumped to and withdrawn from any single tank. Other methods of accomplishing the thickening of fresh sludge include flowing slowly through what is essentially a mechanical clarifier. Obviously digestion tanks will in a measure perform this thickening and mixing function. It is desirable, however, even with digested sludge to provide a holding tank so that a considerable amount of uniform sludge may be available for any filtering run.

The last step in conditioning sludge for filtration comprises the addition of various chemicals to increase the rate at which the solids will give up their accompanying water. This is usually an essential step, there being practically no instances on record where it has been dispensed with for very long. The chemicals commonly used are, in the approximate order of their relative importance, ferric chloride alone, ferric chloride and lime, chlorinated copperas, ferric sulfate, and lime alone. Other conditioning agents which have been used include aluminum sulfate and paper pulp.

Economical operation requires rather close control of the dosage of conditioning agent. Too little chemical results in poor filter yields, high filter cloth maintenance and generally unsatisfactory performance. Too much chemical may have much the same effect. Dosages are partially controlled through the pH determination in some cases and through the filtrate alkalinity in others. As with any production operation however, the final judgment is usually based on the record book, which in the end reveals the results produced and the costs involved. Every sludge seemingly has characteristics all its own and accordingly no sure-fire control routine can be laid out in advance of actual operating experience.

Conditioning agents, in liquid or solid form, are metered to the sludge by means of adjustable feeders, many types of which are on the market. The conditioning agent must be thoroughly mixed with the sludge to secure uniform conditioning. This is usually accomplished by means of mechanical stirring devices, although air has been employed for this purpose in some installations. Immediately after being mixed the sludge should be conveyed to the filters. The conditioning reaction is usually reversible and accordingly a continuous conditioning setup will ordinarily give better results than are obtainable from a batch process, which necessarily delivers to the filters conditioned sludge of variable age.

The optimum quantities of conditioning chemicals necessary to bring about the desired effect in the sludge can be determined fairly closely by mixing small trial batches and filtering them in Buchner funnels, noting either the time required for the cake from a given amount of sludge to crack and release the vacuum, or the amount of filtrate produced from a given quantity of sludge in a given time. Actually there are probably as many different conditioning doses employed in plant practice as there are plants employing the process and further the required dose may vary from day to day in the same plant. Average operating doses reported in the literature indicates ranges varying from approximately 2.0 per cent ferric chloride and 6 per cent lime up to 6 to 8 per cent ferric chloride alone, based on dry weight of the solids in the filter cake.

With digested sludge there appears to be opportunity for cutting down conditioning chemicals by washing sludge prior to conditioning. This process, known as elutriation, consists of diluting the sludge with fresh water or even sewage, allowing it to settle and decanting off the supernatant. Digestion gives rise to certain soluble compounds which use up conditioning chemicals without adding anything to the conditioning effect. By washing the sludge in the above manner part of these compounds are removed.

Filtration of properly conditioned sludge is largely a mechanical matter and will not be discussed here further than to point out that the various filters on the market today will perform satisfactorily if operated with a fair degree of intelligence.

Operating Costs

Operating costs for vacuum filtration comprise those incident to—

(*a*) Labor.
(*b*) Chemicals.
(*c*) Power.
(*d*) Filter Cloths.
(*e*) Maintenance.

Labor costs are nominal. Under ordinary conditions one man only should be required to carry on all the operations incident to filtering up to and including the production of the filter cake. Furthermore, in the average small or medium sized plant one man should be able in addition to tend to most of the strictly routine operating duties in the balance of the plant.

Chemical costs reported in the literature vary widely as may be expected from the dosages employed. At current prices it would seem that these generally range from $1.50 to $5.00 per ton of dry solids filtered, although there are a few plants reporting chemical costs both above and below these figures.

Power requirements for filtration, not including any pumping which may be necessary between the storage tanks and the conditioning equipment should not exceed, say, 25 kwh. per ton depending upon the yield which can be obtained.

The cost of keeping the filters supplied with cloths is another item which varies widely. When acid conditioning is employed, rather costly woolen blankets are generally used. Alkaline conditioning however will permit the use of cheaper cotton material. Filter cloths are subject to rotting and it is frequently found that their life is a function of time rather than production. All factors considered, it would seem that $0.03 to $0.05 per ton should cover the cost of cloths.

In common with all mechanical processes, maintenance can be high or low depending upon the quality of the equipment and the intelligence with which the maintenance program is prosecuted. The equipment involved in vacuum filtration reached its majority years ago in the metallurgical field and the manufacturers have had ample time to design the "bugs" out of it. Certainly an annual figure of 2½ per cent of the equipment cost should cover this item, assuming practically full time operation.

Cost and Operating Data from Neenah-Menasha

At Neenah-Menasha fresh sludge is pumped to either of two storage tanks, where it is held ordinarily for about three days before going to the filters. Sludge at about 10 per cent and solids is pumped from storage to the conditioning equipment where it is treated with hydrated lime before flowing by gravity to the filters. Filter cake containing from 30 to 35 per cent solids is produced and is disposed of by heat drying and incineration.

Operating results for 1940 are given in Table I.

TABLE I

Solids filtered—Dry weight	5029.1 tons
Hours operated	6816.7
Lime used per ton dry solids (CaO)	3.7%
Solids content of Cake	32.0%
Filter yield lbs. dry solids/sq. ft./hour	4.11
Power per ton dry solids	24.2 kwh.

Operating costs for 1940 are given in Table II.

TABLE II

Operation		
Labor	Per ton dry solids	$0.514
Chemicals	" " " "	0.510 *
Power	" " " "	0.317
Filter cloths and wire	" " " "	0.270
Miscellaneous	" " " "	0.084
Total operation		$1.695
Maintenance		
Labor	" " " "	0.055
Supplies	" " " "	0.043
Total maintenance		$0.098
Total operation and maintenance		$1.793

* Not including cost of ferric chloride used on experimental basis.

It may be seen from the above data that the filters actually operated approximately 78 per cent of the time based on a full 365-day year. Most of the down time was, as a matter of fact, occasioned by either lack of sludge, holidays, or maintenance of other equipment ahead of or following the filtering equipment and it is estimated that had they been called upon to do so the filters could easily have operated well over 95 per cent of the time.

As pointed out previously, the solids content of the cake, the required amount of conditioning chemical, the filter yield and the power requirements per ton are more characteristic of the sludge being handled than of the filter equipment. At Neenah-Menasha the sludge consists roughly of one part of domestic solids to perhaps ten parts of waste solids from paper mills and accordingly is undoubtedly radically different from any likely to be met with elsewhere.

The labor cost shown in Table II represents one half of one man's time for every hour the filters operate plus a small amount of additional time required when filters are being washed or cloths are being changed. The filters do not, however, require constant attention, and without doubt the charge made would not have been materially higher had there been four, six or even eight filters to operate instead of two.

Chemical costs for lime only are reported, although there was some ferric chloride used experimentally in 1940. Inasmuch as the use of lime alone was an established procedure both before and after the period during which the iron was used it is fair to disregard its cost in a discussion of this type.

Miscellaneous operating charges include the estimated cost of the water used in washing filters and may be higher than actual. This charge is arrived at by arbitrarily assuming that the filters used 60 per cent of the water metered to the plant.

Maintenance charges for 1940 are approximately 50 per cent higher than they were in 1939 due to the necessity of replacing the bridging behind the cloths on both filters. This replacement is expected to last for a number of years.

Operation and maintenance costs for the Neenah-Menasha vacuum filters in 1940 are shown to amount to $1.793 per ton of dry sludge solids. Whether these costs are high or low as compared to the costs of operating and maintaining other types of sludge disposal facilities is a question the writer would like to be able to answer but cannot. The literature is not replete with articles containing reliable data on the actual costs of operating and maintaining sludge beds. Further, the few such as have been found utilize bases so different from that on which the above costs were worked out that strict comparisons are hardly practicable. It is the writer's opinion, however, formed through a consideration of such information as is available, that the Neenah-Menasha costs do compare favorably with those from most any other plant handling approximately the same amount of solids. Should exception be taken to this opinion the writer would welcome any data which would justify the disagreement.

FILTRATION OF SEWAGE SLUDGE AT LANSING, MICHIGAN *

By George Wyllie

Superintendent, Lansing, Michigan, Sewage Department Plant

The subject of sludge filtration has been rather thoroughly covered in articles by Van Kleeck and others in the last few months. In this paper I will attempt to give some of the results and problems encountered at Lansing in the vacuum filtration of digested sludge. It might be well to call attention to the fact that our sludge differs from that in most other plants in that it contains ground garbage.

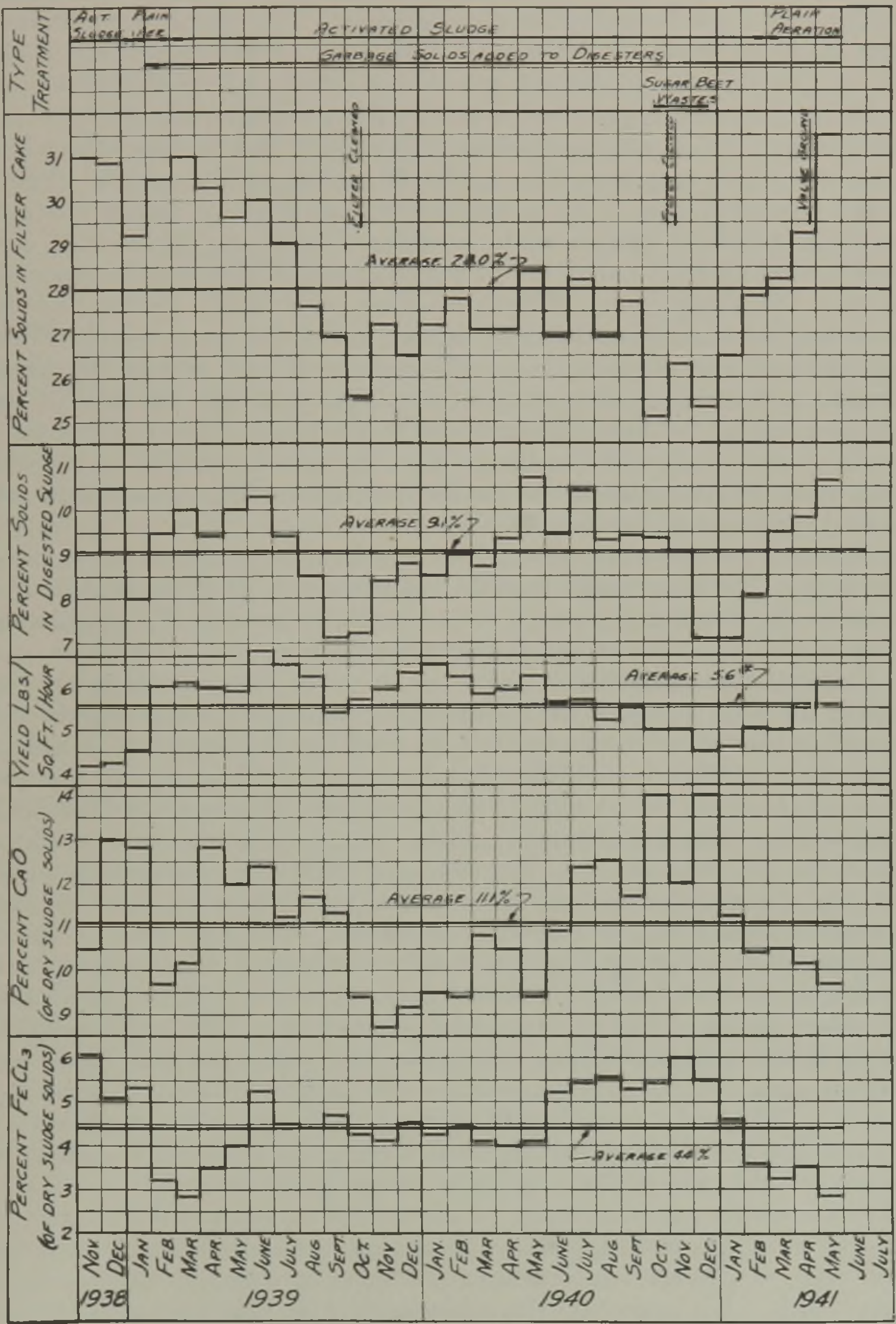
Sludge is dewatered at Lansing by means of vacuum filters. Digested sludge is delivered to the sludge conditioning tank by a bucket elevator equipped with a variable speed drive. The conditioning tank is divided into three compartments by baffles and is equipped with stirring mechanism. The speed of stirring can be regulated. As operated, the detention time in the conditioning tank is about seven minutes. Provision is made for the introduction of lime and ferric chloride. The conditioned sludge is introduced in the bottom of the filter vat through a single opening in the center. The filter is a conventional vacuum filter with a drum 8 ft. in diameter and 8 ft. long. The effective area for filtering is 200 square feet. The cake is removed from the drum by means of air blow and a scraper blade and is discharged on a belt conveyor which carries the cake to a multiple hearth rabble arm type of incinerator, where the cake is either burned or dried.

The operating results of a vacuum filter are dependent upon several factors and in an attempt to see if there was any relationship between these various factors I have plotted the average monthly operating results since we first placed the filter in service (Fig. 1). The data plotted give the yield in pounds of dry sludge solids per sq. ft. per hour, the per cent CaO based on dry sludge solids, the per cent anhydrous ferric chloride based on dry sludge solids, the per cent solids in the filter cake, and the per cent solids in the digested sludge.

The chart also indicates the time when any changes were made in the treatment process which might have affected the character of the digested sludge. When we first started sludge filtration, the sludge was a mixture of digested primary and activated sludge. During part of January and in February, 1939, the activated sludge process was discontinued and sewage was given plain aeration treatment only. Since March 1, 1939, ground garbage has been added directly to the digesters, with the exception of a few brief periods when the ground garbage was added to the sewage. During part of October, all of November and part of December, 1940, a portion of the wastes from the local sugar beet plant was treated at the sewage plant. During March,

* Presented at the Seventeenth Annual Conference of the Michigan Sewage Works Association, Lansing, June 18, 1941.

April and May, 1941, the activated sludge process was again discontinued and plain aeration treatment substituted. All of these factors undoubtedly had some effect on the character of the digested sludge



FILTER DATA - LANSING, MICHIGAN

FIG. 1.

and are no doubt reflected in the operating results obtained. I have also noted on the chart the times at which the filter was given a thorough cleaning.

To date, the average yield of filter cake has been 5.58 lb. per sq. ft. per hr. with a solids content of 28.0 per cent. This result was obtained from digested sludge containing 9.1 per cent solids treated with 11.1 per cent calcium oxide and 4.4 per cent anhydrous ferric chloride.

There does not appear to be any striking relationship between the data plotted, which may be explained because of the various changes in treatment which may have altered the filtrability of the sludge. There would, however, seem to be an indication that digested sludge containing little activated sludge could be filtered with the addition of less conditioning agents. Also, the presence of sugar beet wastes appeared to make the sludge more difficult to filter. Our filter operators have experimented on adding the conditioning agent at various points in the mixing tanks and we seem to get the best results by adding the ferric chloride to the sludge as it enters the mixing tank and the lime at the opposite side of the first compartment in the tank. This practice does not tie in very well with the theory that the lime is used to reduce the ammonium bicarbonates in the sludge and thus make it possible to use a smaller amount of ferric chloride.

We use a high calcium pebble lime which we purchase in paper lined jute bags. We have found that the addition of a small amount of live steam to the slaker maintains a better temperature with less regulation of the water fed to the slaker and gives better operating results.

Originally we purchased ferric chloride in the crystal form but during the past summer we installed the necessary equipment in the way of rubber lined tanks so that we could purchase the material in liquid form. This installation has been greatly appreciated by the filter operators as the handling and dissolving of the crystal form took considerable time and trouble. Also, slivers from the wood barrels and from the wood trays in the solution tanks were continually plugging the ferric chloride feed lines which resulted in improperly conditioned sludge being delivered to the filter. The purchase of ferric chloride in liquid form has practically eliminated all troubles from ferric chloride feeding and resulted in a saving of $2500 on the ferric chloride purchased during the last budget year. The ferric chloride as received varies in strength and is diluted to 35 per cent $FeCl_3$ in our storage tank. This stock solution is still further diluted when transferred to the tanks serving the feeder, to 27 per cent. Just before feeding the solution to the digested sludge more water is added to reduce the strength of the solution to 10 per cent.

Filter cloths are purchased locally and we have not done much in the way of experimenting with various types of cloth. The first cloths used were ten ounce canton flannel, and we are now using an eight ounce cloth. We have experienced considerable difficulty with the so-called "blinding" or clogging of the cloths due to carbonate deposits, which greatly reduces the hours run per cloth. Since starting filtration we have averaged 144 hours service for all cloths including some which were washed and re-used. The maximum run was 355 hours and the minimum 50 hours. This latter cloth was one that was washed in a dilute acid solution and then re-used. This practice has been discontinued as we do not feel the additional service that can be gained in this manner justifies the time and expense of removing, washing and replacing the cloth. Studies at the Minneapolis-St. Paul Sanitary district on short-lived filter cloths indicated the composition of the "blinding" at their plant fell into the following ranges:

	Per Cent
Calcium carbonate	85 to 93
Grease	3 to 8
Ferric hydroxide	1.6 to 3.7
Insoluble (mostly silica)	1 to 5.0

The quantity of blinding material was found to vary from 8 to 29 grams per square foot. These results would indicate that lime was the principal cause of "blinding." We have tried to hold the lime dosage to as low a point as possible but so far we have failed to eliminate the blinding of cloths and the building up of carbonate deposits in filter, filter piping and filtrate pump. Tests with Buchner funnels in the laboratory indicate that we get the best coagulation of the sludge when enough lime is added to give a pH in the filtrate of 10.3. Laboratory tests also indicate that the addition of more lime fails to increase the pH in proportion to the lime added so that it is rather easy to overdose with lime. However, carbonates tend to precipitate out of a solution at a pH much above 8.7, so even with the theoretically correct lime dosage we would still expect trouble from "blinding" due to carbonates. Perhaps elutriation is the answer to the problem although laboratory tests indicate that we would still have to use some lime to coagulate our sludge properly.

The carbonate deposits in the filter, piping and filtrate pumps have given considerable trouble. You will note on the chart giving operating results that the filter was thoroughly cleaned on two occasions, the first time after about one year's operation and again about a year later. On the first occasion we removed the screens, drainage strips and blowback strips and thoroughly cleaned them. The method used was to remove all the carbonate deposits that could be broken loose by pounding with a light hammer and by scraping and then placing the pieces in a vat filled with approximately a 10 per cent muriatic acid solution. As soon as all signs of reaction had stopped the pieces were removed from the bath and thoroughly rinsed with water. It took about one week to do this work using our regular crew to do the work.

Last fall we again cleaned the filter thoroughly except that we did not attempt to clean the wood strips but replaced them. The screens were cleaned by sand blasting at a local industrial plant. The carbonate deposits on the pipe connections to the drum were so bad it was deemed necessary to remove all the piping from the interior of the filter for cleaning. We found some of the pipes practically closed with lime deposits, especially at the elbow where the pipe nipple joined the piping. There was a total of 144 pieces of 1 in. pipe with a total length of 254 ft. and some 96 fittings to be cleaned. We drilled out the pipe using a heavy duty hand drill and regular steel bits welded to longer shanks. Progress was slow but later we made better time by placing the pipes in a dilute solution of inhibited muriatic acid. In some cases it was necessary to run a small drill through the pipe and then finish the job with a ¾ in. drill.

We believe now that we can keep the filter in good shape by periodic acid treatment without removing the screens or piping and plan on doing this about every three months. Under this scheme we remove the filter valve and plug up the outlets of this connection to the filter pans. A 5 to 10 per cent solution of inhibited muriatic acid is applied to the various sections of the filter while they are in the upper position.

SLUDGE FILTRATION AT MUSKEGON, MICHIGAN *

By C. T. Mudgett

Superintendent, Muskegon Sewage Treatment Works

The filters at Muskegon consist of two small units, 3 ft. diameter by 6 ft. long, 55 sq. ft. cloth area on each with common lime and ferric feeds, conditioning tank and feed equipment. Each filter has an assembly of filtrate pump, vacuum pump, and compressor driven by 5 H.P. motor.

Sludge conditioning was designed to be accomplished by pumping at a constant rate with a diaphragm pump into a tank with overflow and underflow baffles. Ferric chloride was admitted from a Chlor-O-Feed pump, and lime from a dry chemical feeder flushed by water into the tank. With a constant rate of sludge pumping the chemical dose was to be varied to give a properly conditioned sludge after being mixed by passing over and under the baffles and agitated by compressed air admitted through filtros tubes. The conditioning tank was equipped with a float controlled switch which turned off the sludge pump and chemical feed motors when the tank was full. In operation it isn't done exactly this way. (The idea was, it was stated by the factory representative, to start the filter in the morning and shut it down in the evening: that was all there was to it.)

The bucket elevator picks up the conditioned sludge from the conditioning tank and dumps it from the end of the buckets into a trough from which the sludge runs by gravity through a 4 in. pipe to the drum tanks. The sludge in this tank is agitated slowly until the filter takes it away. Overflow of the drum tank is prevented by an adjustable overflow pipe connected with the feed pipe lines.

The filter drums, cylindrical in shape, are made of redwood stays tightly fitted to make an air-tight shell. On the outside surface of this shell are placed horizontal strips dividing the surface into sixteen sections. On top of the strips is wire mesh over which the filter cloth is wired.

The filtrate discharges into the vacuum receiver. The filtrate pump takes it from here and pumps it back to the raw sewage. The vacuum pumps operate with seal water. The air and this seal water are discharged together and were piped to the same drain to which the laboratory sinks were connected. Nothing happened when the one filter was started but when the two were put on together the chemist dashed out and said, "Some one on the roof just dumped a pail of water down the hood vent." Investigation showed that the air from the vacuum pumps was blowing the water out of the sink traps. This piping was changed.

Next the filter cloth wash water and conditioning tank drain was piped into the digested sludge well. This wasn't so good because this

* Presented at the Seventeenth Annual Conference of the Michigan Sewage Works Association, Lansing, June 18, 1941.

water either came back to the filter the next day with sludge, or the sludge well had to be completely drained before the days supply of sludge was added. It was very inconvenient so the piping was changed.

The feed piping from the bucket elevator to the filter drum tanks was only a 3 in. pipe and would not pass enough sludge to keep the filters going. This was changed to a 4 in. pipe and if there had been room it should have been 6 in. pipe. In fact, in my opinion, no sludge pipe should be less than six inches.

The last piping change was on the filtrate lines and this was changed to a pipe discharging directly into the grit chamber and laid in the open for easy removal to clean the lime out of it.

Conditioning was another problem: the lime feeder was all right but the ferric pump just wouldn't feed sufficient solution for conditioning purposes so the pulleys were interchanged. This doubled the speed of the pump. Then by keeping the concentration of the solution at about 30 per cent $FeCl_3$, enough was furnished. This concentration was too high, so a mixing chamber was placed above the conditioning tank, and water added to the ferric chloride at this point cut down the concentration.

The bucket elevator was designed with open buckets which were to discharge from the end. In operation it was found that if the elevator was run slowly enough most of the sludge did discharge from the end, but if the elevator was speeded up, and something had to be done to furnish sludge, about half was discharged back into the conditioning tank. This sludge dropping back was agitated too violently, the floc was destroyed and the conditioning ruined past recovery. To solve this problem the manufacturer sent closed buckets that had to discharge from the end. Further, it was found that the best way to deliver conditioned sludge to the filter was to pump sludge into the conditioning tank at the same rate the filters were using it. At the same time the sludge in the conditioning tank is kept low, so low that it never gets to the top of the overflow baffles but runs through the drains in these baffles. The discharge of the bucket elevators is also controlled, to a certain extent, by the depth they dip into the sludge. This sounds complicated and maybe it is. To accomplish this a variable speed drive was placed on the sludge pump. This feature is also handy in other ways: the chemical dose can be controlled, within limits, by a change in rate of sludge pumping without touching the chemical feeds and the effects of partial plugs in the sludge pump can be overcome by speeding up the pump, thus keeping a more constant rate without so much check ball cleaning.

You can imagine how automatic this unit is.

The biggest problem yet to overcome is liming of pumps and piping. We have only succeeded in controlling it. The vacuum pumps, to start with, were the hardest hit. They would fill up with lime in a very short time. We originally assumed that filtrate was being drawn in with the air and the lime deposited was from the filtrate. Working on this theory, the manufacturer shipped us a moisture trap which was installed on the pump suction of one of the units. This did not solve it. After considerable experimenting and chemical analyses, it was concluded that just enough filtrate mist was carried with the air into the pump to kill the bicarbonate alkalinity in the seal water and precipitate the carbonates, thus softening the seal water and depositing lime on the pump casing and impeller. To correct this, the quantity of seal water was increased sufficiently to maintain the bicarbonates in the seal water and thus cut down considerably the rate of lime formation. Later the seal water was reduced again and sewage gas admitted to the vacuum pump suction line. Carbon-dioxide in the gas was utilized to maintain bicarbonates in the seal water with about the same results. Occasionally, now the filtrate system goes bad and filtrate is drawn into the vacuum pumps which wrecks the works but ordinarily an occasional washing of the vacuum pumps with inhibited muriatic acid suffices to keep them going. The filtrate pump and piping, the conditioned sludge feed piping and the bucket elevator must be de-limed occasionally. We have found no way to eliminate this nor the one tough job we ran into last year. This was the filter piping inside the drums. These three-quarter inch pipes became almost entirely filled with lime. More than that, no method of cleaning them, of getting into the drums, or of removing the pipe had been provided. It looked like a complete tearing down job. This would be expensive and probably require a service man. We finally decided to cut one of the end plates on its diameter, remove it and have a look. We found the piping placed without a union and the only pipe we could cut was located so it couldn't be threaded nor was there room enough for Dresser couplings. We cut it anyway, removed the piping, reamed it out with a drill to which an extension shank was welded, and replaced the piping with radiator hose. Radiator hose is a necessity, the filters couldn't be put together without it. This was quite a job as there were four of the end plates to cut, remove, replace, and patch up and 64 three-quarter inch pipes to cut in a very awkward position, to say nothing of the pipe cleaning. The next time it will be much simpler.

Our filters are not operated continuously. Their operation varies with the season and with the demand for sludge cake. In routine operation the operator on the night shift starts the filter about 5 A.M. and generally by noon the filter is shut down. The normal operation is five days per week but this is not a set rule. We are interested in producing a cake that can be trucked. For this reason the filters are operated at a fair rate with as little inconvenience to the operators as possible. By operating one filter at a time a higher rate of production can be obtained but in order to cut down the time of filter operation both filters have been operated together. The rate for 1940 averaged 6.2 pounds of solids per sq. ft. per hour with monthly averages varying from 5.2 to 8.2

The sludge cake rolls off from ¼ to ⅜ inch thick, when the filter is running right, with the drums making one revolution in three minutes. This is a surface speed of 3 ft. per minute. The moisture content of the cake runs between 70 and 74 per cent with an average of about 72 per cent.

The conditioning chemicals used are hydrated lime and ferric chloride. The lime averages about 73 per cent equivalent calcium oxide

City of Muskegon, Michigan, Sewage Treatment Plant

Sludge Record, Year 1940

Date	Raw Sludge				Digested Sludge Filtered			
	Gallons Daily	pH	% Solids	% Volatile	Gallons Daily	pH	% Solids	% Volatile
January	13,200	6.1	5.01	77.9	2,120	7.1	7.90	50.0
February	14,100	6.1	4.93	78.4	4,380	7.2	6.85	53.2
March	14,300	6.1	6.05	72.6	3,180	7.2	6.63	53.1
April	13,000	6.2	5.42	75.2	6,670	7.2	6.55	53.0
May	12,800	6.1	5.70	74.3	4,100	7.2	6.50	53.5
June	13,200	6.1	6.10	70.2	2,850	7.2	6.40	50.6
July	12,600	6.1	5.40	70.9	4,850	7.2	7.20	50.3
August	12,900	6.1	5.49	66.8	7,600	7.2	6.35	51.4
September	12,400	6.1	5.12	70.8	5,580	7.2	7.25	48.2
October	12,700	6.1	5.18	74.1	5,260	7.2	6.45	50.0
November	12,050	6.0	5.45	75.6	2,330	7.2	7.29	50.5
December	13,200	6.1	5.65	73.3	3,170	7.2	8.10	51.2
Avg.	13,000	6.1	5.46	73.4	4,350	7.2	6.86	51.3

City of Muskegon, Michigan, Sewage Treatment Plant

Sludge Filter Report

Year 1940

Date	Hours Operated		Lb. Solids, Dry Basis	Chemicals				Rate	Cake
				$FeCl_3$		Hyd. Lime			
	No. 1 Unit	No. 2 Unit		Lb.	% of Solids	Lb.	% of Solids	Lb./Sq. Ft. per Hour	Cu. Yd
January	8	93	44,630	1,238	2.8	5,170	11.6	8.2	118
February	119	70	75,010	2,294	3.1	8,105	10.8	7.3	194
March	71	60	55,550	1,661	3.0	6,200	11.1	8.0	149
April	167	154	111,520	2,743	2.5	11,560	10.3	6.5	275
May	105	115	70,640	2,037	2.9	7,850	11.1	6.0	190
June	83	83	47,120	1,443	3.1	5,700	12.1	5.2	121
July	94	184	90,300	3,111	3.4	10,580	11.7	6.0	238
August	231	191	128,660	3,986	3.1	14,930	11.6	5.7	344
September	155	156	104,780	2,914	2.8	9,840	9.4	6.3	255
October	151	152	89,920	2,456	2.7	9,530	10.6	5.5	228
November	62	62	43,730	1,126	2.6	4,450	10.2	6.5	106
December	90	92	68,070	1,822	2.7	6,425	9.4	7.0	170
Avg., 1940	229		77,500	2,240	2.9	8,370	10.8	6.2	199
Avg., 1939	184		77,400	2,310	3.1	8,710	11.2	7.8	197

City of Muskegon, Michigan, Sewage Treatment Plant
Sludge Filter Cost Data
Year 1940

	Total	Per 1000 Gallons Sludge	Per Ton Dry Solids
Operation			
Power @ 1¢ per K.W.H.	$ 137.40	$ .087	$ .331
Ferric Chloride	898.84	.565	2.160
Lime	501.73	.316	1.205
Labor (Estimated)	1,500.00	.945	3.610
Truck	160.00	.101	.385
Filter Cloths and Acid	126.91	.080	.305
Maintenance and Repairs	—	—	—
Total Operation (Gross)	3,324.88	2.094	7.996
Capital Investment—$9,000 Depreciation and Interest @ 5% each	900.00	.577	2.160
Total Cost	4,224.88	2.660	10.160
Revenue	808.26	.509	1.940
Net Operation Cost	2,516.62	1.585	6.056

Cost per M.G. of Sewage	
Operation (Gross)	$2.05
Fixed	.56
Total	2.61
Cost per Unit of Raw Sludge (Gross Operation)	
1000 Gallons	$ .697
Ton of Dry Solids	3.00
General Data:	
Total Gallons of Sludge Filtered	1,588,835
Total Tons of Solids Filtered (Dry Basis)	416
Total Power Consumed @ 5 K.W.H./Filter Hr.	13,740
Hydrated Lime Used—73.4% Calcium Oxide	

and is recorded as hydrated lime. The average consumption for 1940 was 10.8 per cent of sludge solids which if figured on a calcium oxide basis would be 7.9 per cent. Crystal ferric chloride has been used and is recorded as anhydrous. The average consumption for 1940 was 2.9 per cent of sludge solids.

The analytical data are summarized in the accompanying tables. I might state here that our records for filter rate and chemical consumption are based on the actual pounds of sludge solids filtered. Some authorities have recommended that the chemicals be added to the sludge solids for these determinations. We feel that since the chemicals added are a necessary evil and our problem is actually that of dewatering sludge the filtration records should be based on sludge solids.

The filtrate removed from the sludge runs between 1000 and 3000 p.p.m. total alkalinity. It has a low B.O.D. and very low bacterial count and coli index.

Canton flannel filter cloths were used at the start, with such good luck that we didn't try anything else. A new cloth is run until the rate slows down and it blinds easily, then it is washed with about 25 per cent inhibited muriatic acid. Filter cloth data follow:

	Per Cloth	Per Sq. Ft. Filter Area
Gallons of sludge filtered	263,600	4,800
Tons of dry solids:		
Before acid washing cloth	24.5	.44
After acid washing cloth	52.7	.96
Total	77.2	1.40
Acid used per cloth, lb.	38.4	.70
Filter hours operation	450	
Cu. yd. cake	400	73

To date we have had little difficulty in disposing of the sludge cake. It is sold for 50c per cu. yd. to anybody that calls at the plant for it. If their truck is suitable and they make proper arrangements it is dumped in their truck from the hopper; if they have a trailer they must shovel it from the stock pile. We also deliver to any place in Greater Muskegon for $1.25 per cu. yd. in 3-yd. loads or, if less than three yards is desired, the unit price increases. Considerable cake was used on the plant grounds, the park department also uses it on the parks, spreading it during the freezing weather so the frost will break it up for them. The total income from sludge sales in 1940 was $808.26.

The total operating cost of the filters for 1940 was $3,324.88 which was equivalent to $8.00 per ton of solids. Deducting the revenue, the net cost was $6.06 per ton of dry solids. The total capital investment was $9,000 and fixed cost may be figured as you please. I have used 5 per cent for depreciation and 5 per cent interest. The costs are summarized on the accompanying table.

Let me state in closing that, even though the filters develop a few headaches and at times the air is blue, we still like these filters and appreciate the fact that sludge may be drawn from the digesters every day without worry of cleaning a bed before sludge can be drawn. We like the problems that arise from their operation and whatever has been stated in this paper has not been in the spirit of criticism but in the spirit of helpfulness to the designer and operator to aid in correcting the features, as far as possible, that cause the headaches.

PAINT SPECIFICATIONS FOR SEWAGE WORKS *

By W. T. McClenahan

Senior Civil Engineer, The Sanitary District of Chicago

The subject of paints for sewage works is too broad and too complicated to be covered properly in this short paper. Conditions vary between plants and even between different parts of the same plant, so that paints suitable for one place may not be at all suitable for another place. Moreover, the science of paint and varnish making has, for a number of years, been in a state of flux. Theory has been advancing greatly and many new and remarkable products have been brought out by and for the paint industry. To keep abreast of the times it is necessary to be continually reorienting our views with regard to proper paints for our service. The advance in paint technology has been brought about largely by the introduction of tung oil from China, synthetic resins from various laboratories and new types of solvents and thinners. Because of these materials wide research has been undertaken, not only by the promoters but also by many other competent organizations, so that today the making of paints and varnishes is less of an art and more of a science than it has ever been.

World wars, however, have broken upon us. Our standards for paint making are being upset. We are confronted by various kinds of shortages which necessitate resort to various expedients and untried substitutes. Tung oil, for instance, has become quite scarce because of the war in China. Much of what we get from the Orient has been adulterated and much of it has soured in transit. In either case the varnish making value of the raw oil has been depreciated.

Shortages have also been brought about by the United States Government appropriating certain materials for our national defense. Chief among these items are the metals aluminum and zinc, from which aluminum paste, zinc dust, zinc oxide and other pigments are made. Aluminum paste and zinc dust have practically disappeared from the market and zinc oxide and zinc chromate will soon be gone.

Certain resins also, or rather some of the ingredients which go into the making of resins, have also been appropriated, so that varnish vehicles made of these resins are now less easily obtained. Moreover, certain thinners and solvents have use in our national defense program and so are being restricted for civilian use.

Because of all these scarcities we must find suitable substitutes for some previously well known and generally used materials. The writer confesses that at times he is greatly perplexed when it comes to specifying substitutes for some of these materials. In certain cases, where no good substitute appears readily at hand, we have adopted the policy

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of providing only temporary protection to the steel, hoping that before the paint has failed the war will be over.

Because of the more or less transient nature of the present situation, the writer thinks that it will be best to ignore the existing scarcities in this paper and to treat the subject of paints for sewage works as if all materials could be readily secured.

To keep the discussion within reasonable bounds the paper will deal only with the preparation and painting of steel surfaces and mainly with priming paints for these surfaces. Discussion will be presented under appropriate heads, viz:

Conditions for Paint Destruction (Exposure).
Preparation of the Surface and Proper Paint Application.
Basis for Good Paint Formulation and Paint Combinations.
Proper Methods of Specifying Paints.

Conditions for Paint Destruction

On sewage works, paints are usually exposed to the following conditions:

1. Surfaces are submerged in water or sewage.
2. Surfaces are exposed to sunlight and weather.
3. Surfaces are exposed to foggy atmospheres directly above sewage.
4. Surfaces are exposed on the interiors of buildings where they are usually kept dry, but possibly subject to small amounts of hydrogen sulfide.

(1) In the first named exposure, paints are destroyed mostly by:

(*a*) Moisture softening the vehicle.
(*b*) Moisture and hydrogen sulfide penetrating the film to the steel and destroying the paint bond.
(*c*) Oils, greases and emulsified soaps in the sewage softening the paint and making it more susceptible to other types of damage.
(*d*) Sand and grit wearing the film away.
(*e*) Floating debris and machine action doing mechanical damage.
(*f*) Ice doing damage. In the temperate zone ice does not occur except in clean water.
(*g*) Wetting and drying at and near the water line (accompanied by some oxidation) destroying the films.

(2) In the second named exposure, paints are destroyed by:

(*a*) Oxidation, often accelerated by actinic light.
(*b*) Photochemical and similar reactions where two or more molecules of the paint compounds are joined into larger molecules. These reactions are not oxidations, although they may be accompanied by oxidation. Polymerization of the vehicle is the best known type of these reactions.

Some pigments like zinc oxide also join themselves onto some of the vehicle molecules. Such unions cause marked shrinkage of the paint volume and so often result in checking and cracking of the film (due to resulting high tensile stress), loss of bond to the steel, and peeling of the film from the surface. Often the reactions result in a general deterioration of the homogeneity, elasticity and strength of the film as applied.

(*c*) Stress failures brought about by frequent changes in the paint volume. These volume changes are produced by heating and cooling, freezing and thawing, and wetting and drying. They cause internal stresses of various kinds and often rearrangements in the molecular structure. They result in film embrittlement, loss of bond, cracking and other types of failure.
(*d*) Moisture and gas penetration to the steel, either accompanied by or in the absence of actual corrosion of the steel. The moisture and gas collects under the film and brings about blistering and loss of bond.
(*e*) Abrasion of the film by windblown sand.
(*f*) Mechanical or malicious damage.

(3) The third type of exposure, in our experience, is the most destructive of all common exposures and most difficult to combat. Warm wet air arising from the sewage, especially in cold weather, fills the covering building with fog. This moisture condenses on the cold steel and window glass of the building and keeps the paint soaked over long periods of time. The moisture absorbs oxygen, hydrogen sulfide and carbon dioxide from the atmosphere and thus becomes highly acid and corrosive of steel. Changes in the temperature and atmospheric conditions cause this moisture in and over the paint to vary in amount and sometimes even to dry up, so that many degrees of acid concentration are represented over a period of time. Moreover, the paint at the same time is subjected to a wetting and drying action and in cold weather to a freezing and thawing action, both of which cause volume changes and internal stresses.

The corrosive liquid when it penetrates the film attacks the steel and since the iron oxide formed has about eight times the volume of the original steel from which it comes, the film is pushed up, causing blistering, pimpling and other forms of failure. Soon the paint cracks and then moisture, oxygen and acid-forming gas have free access to the steel.

(4) The fourth type of exposure is generally the least troublesome of all those described. The condition is common in offices, laboratories, pump and blower rooms and in other places where sewage is not directly exposed in open surface. Trouble may be experienced, however, from:

(*a*) Hydrogen sulfide discoloring paints which contain lead and certain other pigments such as iron ochre and ferrite yellow.
(*b*) Linseed oil darkening as it ages, especially in dark corners and rooms away from the light.
(*c*) Certain lithopones darkening where they are struck by direct sunlight and whitening where the light is not so strong.

In addition to the above named exposures and types of failures, paints anywhere, if they are kept damp for a long time, may be attacked by molds, yeasts and other biological growths.

Preparation of the Surface and Proper Paint Application

In addition to exposure attacks doing damage to the paint films paints may be damaged by:

(1) Improper or insufficient cleaning of the steel before painting.
(2) Improper formulation of the paint in its manufacture or insufficient mixing of the paint in the can at the time it is applied.
(3) Adding too much thinner or adding the wrong kind of thinner for the type of vehicle used.
(4) Applying too thin a coat.
(5) Leaving pin holes, skips and damaged spots.
(6) Painting on damp steel or in damp or frosty weather.

If an alkali or an acid be used to clean the steel all traces of the cleaning agent must be completely removed or the paint will be damaged.

Moisture must be removed. Perhaps more paint is damaged by painting over moisture or frost than from any other factor. It will pay to spend considerable money to make the surface dry and free from frost. One of the big advantages of the flame treatment of steel before applying paint is that the steel is made absolutely dry. Another advantage is that if the paint be applied while the steel is still hot the paint will be baked onto the steel, increasing its imperviousness to moisture and its adherence to the steel. The finished paint job is then much better than where the paint is allowed to dry in the usual manner. It should be remembered that moisture may be present even though it is not visible to the naked eye. The condition of the atmosphere is a better indication of the condition of the surface of the steel than is the appearance of the steel itself.

All oil, grease, dirt and other adherent must, of course, be entirely removed. No paint is better than the surface to which it is applied. An interposed film which does not cling tightly to the steel or furnish good bond for the paint to be applied over it, or deteriorates from any cause after the paint is applied, is a dangerous film. It is bound to destroy the paint over it, no matter how good that paint may be.

For underwater work or use in damp places the writer believes that steel may profitably be de-scaled. For use in normally dry locations, however, there is less justification for such added expense. It is also advisable to wash the surface of the cleaned steel with phosphoric acid when it is to be used in damp places, and also in normally dry places if the surface has been allowed to rust before beginning the painting work. Otherwise in dry places the wash is less necessary. In any case all loose scale and rust must be removed to a sound base.

In the writer's judgment, where the mill scale is not entirely removed, a shop coat should be added before the steel has had time to rust. It is not satisfactory, in our experience, to deliver the steel unpainted to the field and delay the painting until the steel has been erected, unless the painting can be delayed long enough that all mill scale will come loose. This generally requires that the steel be exposed to the weather from six to twelve months, depending on the time of year and the amount of rainfall. Construction procedure for erecting buildings will not generally allow such long delays and so painting must as a usual thing proceed before all scale lets loose and before it can be thoroughly removed by ordinary scraping and brushing methods. The result is that paint is applied over many islands of tight scale which cannot be removed at the time. These islands of scale may contain considerable moisture and absorbed gas. They have a habit of "popping off" after the paint has been applied and dried, due to an electrochemical cell set up between the damp scale and the steel. Where the steel is painted in the shop before the scale becomes damaged or filled with moisture and acid-forming gas, the protection afforded by a paint applied over it appears to be much better.

In addition to possible poor preparation of the steel surface to receive the paint, the paint itself may be improperly handled. It may be insufficiently stirred in the can so that the pigment-non-volatile volume ratio varies in different parts of the work. Addition of non-volatile oils or varnish to a well balanced paint weakens it instead of strengthening it, as some suppose. Use of clear linseed oil or varnish on the steel before applying the priming paint is also bad practice from a protection standpoint.

Too much thinner affects the durability in a number of ways: (1) it increases the porosity of the dried film due to the greater number of vortices formed as the volatile escapes. Those vortices become pinholes when the paint dries. Moreover, a greater amount of thinner may be entrapped in the paint as it hardens, where too much is used in the mixing, producing a spongy structure when dry. (In this respect, use of too much thinner in a paint is harmful for the same reason that too much water in concrete is harmful.) (2) It spreads the paint out too thin: (*a*) because the paint can be brushed out more easily, and (*b*) because there is more shrinkage in a given volume of paint applied to a given area. (3) Certain resins used in making paint vehicles have what is known as a "tolerance" for certain thinners. Thinners used in excess of this amount cause the resins to be thrown out of the oil-resin chemical combination so that the vehicle is no longer of the same nature. The vehicle is, therefore, damaged when this occurs.

Basis for Good Paint Formulation and Paint Combinations

To protect steel, paint must:

(1) Be as nearly water and gas tight as it is possible to make it.
(2) Adhere firmly to the steel.
(3) Retain its elascity and other good qualities and resist damage by the given exposure.
(4) Inhibit corrosive attack on the steel should water and gas get through the film.

No paint examined thus far has given perfect protection. They all have their weaknesses. We must exercise a good deal of ''engineering judgment'' in accepting paints, especially the vehicle to be used in them. Our judgment may be guided, however, by certain accelerated performance tests of the vehicle, which more or less simulate field conditions. Nevertheless, we cannot at this time expect too precise or clean cut decisions from these laboratory tests of the vehicle, such as we can expect from the testing of cement, cast iron, and steel. The results to be expected are more comparable with those we obtain from the quality tests of concrete aggregates, only they are not quite so definite. Even the best paint vehicles show some degree of failure when subjected to the tests we make.

While accelerated tests of the vehicle are not so good as actual field tests they nevertheless are necessary in order that decisions may be made promptly and in time to be of use to the constructor. He cannot await the results of long time service tests in the field. Moreover, batches of varnish vary in quality between cooks. Each batch should therefore be tested to assure acceptable quality in all cases.

The Sanitary District considers it better practice to test the paint ingredients before they are mixed and then to inspect the proportioning and mixing of these tested and approved ingredients, rather than to try to analyze the paint after it has been made up. It is very difficult to tear the organic constituents of the paint apart after they have been mixed.

We believe that pigments may in most cases be satisfactorily tested for acceptance by appropriate chemical and physical analyses, but vehicles are best tested by accelerated performance tests designed to simulate field conditions. We think that these performance tests of the vehicle should be upon a dried film applied to steel, for it is steel we are trying to protect in the field.

In order to speed up the testing we do not pigment the vehicle when it is being applied in these tests, for it is our belief that while the pigment adds greatly to the life of a paint in the field, nevertheless, the results of the tests of the clear vehicle have a general relationship to the results obtained in the field. A vehicle showing good resistance in the clear when subjected to well designed and field-checked performance tests in the laboratory will invariably show good performance when the vehicle is pigmented and applied to the steel in the field and vice versa a vehicle which shows poor resistance to these same laboratory tests in the clear will not be likely to give very good service when it is mixed into the paint and applied in the field.

We do not, however, try to forecast the life of the paint in the field from these laboratory tests. The relationship seems to be too uncertain.

In our work, chief emphasis is placed on the quality of the vehicle because that part of the mixture furnishes the binder and the waterproofing value.

Two coats are applied to the steel, the first coat being allowed to dry 24 hours and the second coat seven or eight days before subjecting them to the prescribed tests.

Four major performance tests are specified. These tests are intended to simulate our exposure conditions. Minor tests are also prescribed, but these tests are largely to assure good working qualities.

The major tests are:

(1) A cold water test.
(2) A hydrogen sulfide test.
(3) An ammonia test.
(4) An oil-moisture-soap emulsion test.

A copy of these major test specifications is included as an appendix to this paper.

As time permits, we hope to revise these specifications, because the ammonia test seems to be unnecessarily severe and we believe that the cold water test and the hydrogen sulfide test can be advantageously combined into one test to be performed in a moist cabinet which we have recently had built.

While we have never specified the composition of the vehicle to be supplied, the paint manufacturers have always furnished a phenolic resin-tung oil varnish under the performance tests specified.

In addition to the use of a good vehicle, we believe that the priming paint should contain about one-third pigment to two-thirds non-volatile vehicle by volume, in order to produce the greatest density consistent with durability. Top coat paints should contain somewhat less pigment because of needed elasticity, while flat paints generally run much higher in pigment. High density in the priming paint is desirable to increase the resistance of the film to the passage of water and gas.

To inhibit corrosion (passivate the steel) when moisture and gas penetrate the protective film, it has been found that zinc chromate is most effective. In our formulae we have been adding about 10 per cent by weight of the total pigment, but the United States Engineers on the Mississippi River work have found that a 65 per cent addition is even more effective.

While we recognize the merits of this course we have always hesitated to use such high percentages of zinc chromate, because we knew that the pigment was somewhat soluble and, therefore, extractable from the film. We feared that should the pigment leave the film we would no longer have a tight but a pervious film. Nevertheless, because of the shortage of zinc dust and zinc oxide which are used in our present priming paint, we intend to try out higher percentages of zinc chromate in some new formulations as a substitute for those previously used pigments if zinc chromate too does not follow the other pigments into oblivion in the present war emergency.

Lead chromate is also an inhibitor of corrosion. While red lead has always been considered to be an inhibitor for corrosion, the writer has come to suspect that it is the insoluble lead soaps which are formed which add most to the effectiveness of the red lead film and are most responsible for the good record of this old-time pigment.

In formulating a paint, consideration should no doubt be given to the effect of the shape of the particles used in the mixture. Flat, plate-like particles such as those of aluminum and mica tend to arrange themselves in systems parallel to the steel surface. These flakes, therefore, lengthen the route over which moisture and gas must travel to reach the steel and, in effect, increase the thickness of the coating. They also turn the planes of stress weakness in the film in a direction parallel to the steel surface and so add to the life of the film. Rod-like particles such as those of asbestine and acicular zinc tend to reinforce the film. Round and cubical particles tend to fill in the crevices and gaps in the applied film and thus increase the film density. All shapes therefore have their uses if used in proper proportions.

For construction it is desirable that the shop coat dry within 24 hours so that the steel can be moved out of the shop by the next day without serious damage to the paint. Paints with a phenolic resin varnish vehicle usually dry this way so that they have a big advantage in this respect over old fashioned red lead and oil paints.

With regard to paint combinations, it is the writer's opinion that one priming paint may be used for protecting steel everywhere but this coat must be protected by other coats which are particularly suited to the given exposure. In sunlight, the prime coat should be protected by a good coat of aluminum or a good linseed oil or phthalate resin varnish paint. These paints withstand the sunlight much better than do phenolic resin varnish paints, especially the short oil varieties. Below water it has been our practice to apply a heavy coat of asphalt emulsion over the priming paint. This we specify to be of a "dried thickness of 1/16 inch." The reasoning which led us to use of this emulsion was as follows:

The inhibitor pigment in the priming paint, if it is to function at all, must go into solution but that solution strength must be maintained above a certain standard concentration if it is to be effective. The heavy asphalt coating prevents dilution of the inhibitor pigment solution next to the steel and thus lengthens the life of the paint coating as a whole. We have Oliver Filter tubs in service for over five years handling acidified sewage sludge, which are still in excellent condition. These tubs were painted in accordance with this plan.

Proper Methods of Specifying Paints

In specifying paints, two methods are open to the engineer. He may either specify by composition or he may specify by performance. It is not proper for him to use both methods of specifications for one material. If he does he may find that the two parts of his specifications conflict and that it will be impossible for the manufacturer to comply with both requirements.

If he specifies by composition, he assumes the responsibility that the product will give the required performance. If he specifies by performance he should leave the composition to the manufacturer, stating only that he wants the material to do certain things. Each type of specification has its place. A performance specification may, however, with propriety, suggest a composition as having previously given satisfactory performance in order to give the manufacturer a clue as to what material may be used for the purpose.

We have a pretty good idea of what pigments we want in our paints and also what the pigment-non volatile ratio should be. We may, therefore, quite properly specify the exact composition of the paint in these respects for we should know more about what we want than does the paint manufacturer, and we should therefore assume full responsibility for the composition. On the other hand, varnish making is still very much of an art. Using the same materials different varnish makers will produce different varnishes, and so it has always been our practice to specify the vehicle by performance. In the last analysis what do we care how the manufacturer makes the vehicle for our paints so long as it does what we want it to do?

Another desirable feature in a paint specification is that the performance tests be such as anyone can apply anywhere, at any time. It is not proper to specify that the manufacturer shall guarantee paint service for six months, a year or any other time, for the manufacturer has no means of knowing exactly what that service will be. The tests should be simple and easy and such that either the manufacturer or the engineer can take a sample and test it in his own laboratory. Moreover, decisions must not be too long deferred. In general, no test should run longer than about a month. Tests which run longer than this are usually not of much use to the engineer in accepting material for construction.

APPENDIX

The following are extracts from the Sanitary District "Manual of Standard Paints and Painting" of 1936 which cover the four major tests applied to the vehicle for our Priming Paints.

Cold Water.—The varnish shall pass a cold water test.

Test: Test tubes prepared and coated as specified in Appendix V 37 shall be immersed to a depth of 6 inches in distilled water and held at approximately 21° C. for 7 days. Remove and immediately examine the film for blisters, minute pimples and adhesion. Wipe dry, let stand for 30 minutes and again examine for adhesion, gloss and general condition.

When immediately removed the varnish shall be free of large blisters and heavily "pimpled" surface. Small areas or isolated "pimples" will be ignored. There shall be no marked difference in the hardness and adhesion between the soaked and the unsoaked ends although a slight softening will again be ignored.

After drying the soaked area shall exhibit practically the same hardness and adhesion as the unsoaked area, due allowance being made for poor adhesion over blisters.

Varnishes exhibiting severe blistering or discontinuity of surface will be rejected. There shall be no marked reduction of gloss nor whitening.

Hydrogen Sulfide.—The varnish shall pass a hydrogen sulfide test.

Test: Take another test tube prepared and coated as specified in Appendix V 37 and immerse it to a depth of 6 inches for five days in distilled water in a closed jar held at 21° C. During this period slowly bubble hydrogen sulfide through the water sufficiently often to maintain a practically saturated solution of H_2S at all times. Note the darkening of the varnish on the submerged portion. At the expiration of the 5-day period remove the tube and examine the coating for blistering, discontinuity of surface, softening and formation of iron sulfide on the tube surface.

Small blisters may be present but no general separation nor large blisters. A deposit of iron sulfide on the tube surface will be considered a failure.

Ammonia.—The varnish shall pass an ammonia test.

Test: Take another test tube prepared and coated as specified in Appendix V 37 and immerse it for 7 days in a solution containing 10 gm. per liter ammonium sulfate and 15 gm. per liter ammonium carbonate. After immersing the tube cover the surface of the liquid with a layer of neutral mineral oil (Nujol) to prevent escape of the ammonia gas. (The solution should show a pH of approximately 8.5.)

There shall be no pronounced loosening or softening of the film, whitening nor discontinuity of the surface.

Slight "pimpling" of the surface may be expected but the action shall not be severe.

Oil-Moisture—Soap Emulsion.—The varnish shall pass an oil-moisture test.

Test: Prepare an oil-moisture mixture as follows:

Fat Mixture

	Grams Weight
Linseed fatty acids	50
"Perfection" kerosene	100
Crisco	200
Castor oil	150

Then dissolve 1 gm. American Family Soap Flakes in 50 gms. of distilled water and add the suds to the above fat mixture stirring vigorously as the solution cools to make a smooth emulsion. Stir the emulsion until cold.

Then wash a bright steel panel in benzol to remove all traces of oil. Dry carefully and sand paper the surface lightly. Apply one brush coat of the varnish under test to this panel being careful that all brush marks, skips and other imperfections in the coating are eliminated. Allow to dry 7 days. Build a border dam of "plasticine" or similar plastic clay 3/16 in. high all around the edge of the dried panel so that the specimen surface forms the bottom of a shallow tray. Fill this tray with the above test paste and place in a horizontal position in an oven for 72 hours at a constant temperature of 120° F.

After 72 hours there shall be not more than slight discoloration of the metal surface and adhesion shall still be complete. Considerable softening of the film is to be expected but separation from the steel or discontinuity of film shall not occur. The appearance of a marked amount of oil underneath the film will be considered a failure.

Preparation of Tubes. (From Appendix V 37.)—Prepare 1 in. by 10 in. test tubes of No. 24 BWG. steel containing from .10 to .20 per cent carbon. Acid pickle to remove the oxide film, wash thoroughly, rinse in very dilute ammonia, rinse again in hot distilled water and then wipe dry.

Sand paper thoroughly to eliminate etching marks left by the pickling process, then rinse in benzol and dry.

HIGH CAPACITY FILTRATION; THE BIOFILTRATION SYSTEM *

By Frank Bachmann

The Dorr Company, Inc., 570 Lexington Ave., New York, N. Y.

The Biofiltration System of sewage treatment was conceived in the Middle West and underwent its experimental development and initial commercial applications on the Pacific Coast. It is now used very broadly throughout the United States, largely because of its wide application in U. S. Army Training Camps.

Its originator, Harry N. Jenks, a consulting sanitary engineer of Palo Alto, California, conducted his preliminary tests as early as 1927 in a small laboratory unit at Iowa State College on the treatment of milk wastes, and slightly later on packinghouse waste at Mason City, Iowa.

In 1931 and 1932 studies were made on domestic sewage in connection with the treatment of sewage for the cities of Sacramento and Riverside, California. This was followed by experiments with textile waste at Greensboro City, North Carolina, in 1933.

In 1934–35 the Biofiltration System was demonstrated on a semi-plant scale at Santa Ana, California, where the possibility of reclaiming irrigation water from sewage was being investigated. Simultaneously a similar pilot plant was operated at Salinas, California. Further two-stage experimental work was carried on at Palo Alto, California.

The first commercial installation took place in 1936 at San Mateo, California, where a portion of the regular plant effluent was treated for irrigation use. The first large scale plant was put into operation in the same year at Camarillo State Hospital, California.

Since that time about sixty full-scale plants are under construction or operating throughout the country. They have designed capacities ranging from 0.05 to 4.55 m.g.d. Among these are seventeen for the Army Training Camps. The largest municipal installation in the East, 1.0 m.g.d. took place at Liberty, New York, in 1940.

The Dorr Company and Link-Belt Company acquired rights to the Biofiltration System in 1936.

In the Biofiltration System, there are two important considerations —one involving the minimum dose applied to the trickling type filter, the other involving the recirculation of filter discharge material back to a settling or detention tank preceding the filter. The recycled filter discharge material may consist merely of filter effluent, or of overflow or underflow from a secondary Clarifier following the filter.

Some of the characteristics of Biofiltration, but not all necessarily essential elements of the process, include the following: pre-sedimentation of the sewage before it is applied to the filter; the use of dosing

* Presented at the Spring Meeting of the New York State Sewage Works Association, Niagara Falls, June 19–21, 1941.

rates on the filter in excess of 800 gal. per cu. yd. of filter meduim per 24 hours; clarification of the filter effluent in either the detention tank preceding the filter or in a separate Clarifier; recirculation of filter effluent, final Clarifier overflow, or final Clarifier underflow back to the new incoming feed; the use of filter beds having stone depth as shallow as 3 ft.; the use of two-stage treatment where very strong sewage is encountered, or where a high degree of treatment is desired; high filter loadings based on raw sewage; and substantially continuous filter dosing.

The continuous passage of the sewage and recirculated effluent through the system at a relatively high rate causes a uniform action to take place throughout the entire depth of the filter bed. Also, the surface of the filter is kept wet at all times, and the detention period in the settling or detention tank never becomes excessively long. This results in a uniform action throughout the filter bed depth (particularly a shallow one), continuous filter bed unloading, and prevention of surface ponding and filter fly breeding.

Because of the relatively short detention or contact period in the filter, complete stabilization is not secured in the filter alone. This unit rather acts as a "decolloider" and serves to coagulate the colloidal material and agglomerate the very fine particles in the sewage in much the same way as is accomplished in chemical precipitation processes and to a considerable degree in the first stages of the activated sludge process. At the same time, however, there is an appreciable reduction in B.O.D. and a build-up of dissolved oxygen which is utilized to complete the stabilization in the detention tank. In this way the Biofiltration System may be considered as the full equivalent of the activated sludge process, the filter being the source of oxygen and micro-organisms, and the Clarifier or detention tank serving as an aeration tank as well as a settling tank.

Standard, low-rate, trickling filters are from 6 to 10 ft. deep, whereas most Biofilters now in operation and under construction are 3 ft. deep. The 3 ft. depth bed is most economical on a total cost basis, considering the reduction in permissible loadings for deeper beds. The 3 ft. bed is more effective per cubic yard of material, has less chance of being clogged, and maintains an adequate oxygen supply.

Crushed stone of 2 to 3½ in. in size has been used in primary Biofilter beds and 1½ to 2½ in. stone in the secondary beds. The method of supporting the stone is similar to that used on the standard type low-rate lter. With shallow filters, forced ventilation is not used, as it is felt that sufficient ventilation is available by natural means.

Experiments and commercial installations indicate that the ability of a filter to remove B.O.D. varies greatly, depending on the strength and character of the sewage. Much is yet to be learned regarding the capacity of filters, but data acquired indicate that the stronger the sewage, the greater the removal of B.O.D. per cu. yd. of filter material on a high capacity filter. Also, it has been noted that the capacity of the filter for B.O.D. does not fall off as a result of overloading.

Biofiltration Plant Installations*

Arranged Chronologically According to Type — Single, Two and Three-Stage

No.	Location	Year Built	Design Flow M.G.D.	No. Bio-Filters	Bio-Filter Size Dia. Ft.	Bio-Filter Size Depth Ft.	Max. Filter Design Dos. Rate M.G.A.D.
	SINGLE-STAGE						
1	Camarillo State Hosp., Cal.	1936	1.0	1	85	3	38.8
2	Modesto, Cal.	1937	3.0	1	90	3	61.2
3	Placerville, Cal.	1938	1.0	1	60	3	77.0
4	Dayton, Wash.	1938	0.76	1	100	3	20.0
5	Walla Walla, Wash., State School	1938	0.05	1	20	3	41.7
6	Stockton State Hosp. Farm, Cal.	1939	0.5	1	45	4	42.2
7	Sonoma State Home, Cal.	1939	1.0	1	100	6½	24.0
8	Loveland, Colo.	1939	0.8	1	60	4	47.8
9	Mendocino State Hosp., Cal.	1940	1.0	1	85	3	18.2
10	Seminole, Okla.	1940	0.75	1	58	3	36.0
11	Leavenworth, Wash.	1940	0.2	1	41	3	20.0
12	Walla Walla, Wash., Camp	1940	0.3	1	20	4	40.0
13	Wellman, Iowa	1940	0.2	1	36	7	21.0
14	Ceres, Cal.	1940	0.3	1	45	3	24.0
15	San Juan, Cal.	1940	0.1	1	40	3	10.0
16	Fort Bragg, N. C.	1940	4.55	2	134	3	45.0
17	Oakdale, Iowa	1940	0.3	1	34	3½	13.8
18	Marine Rifle Range, San Diego, Cal.	1940	0.35	1	55	3	26.0
19	Centralia, Mo.	1940	0.3	1	35	3	41.0
20	Camp Edwards, Mass.	1940	3.0	2	100	3	29.2
21	Federal Correction Inst., Sandstone, Minn.	1940	0.18	1	36	6	7.7
22	Dyersville, Iowa	1940	0.25	1	75	9	4.1
23	Nevada, Iowa	1940	0.29	1	75	8	5.7
24	North Girard, Pa.	1940	0.48	1	32	6	35.2
25	Scranton, Iowa	1940	0.26	1	26	7	21.2
26	Crownsville State Hosp., Maryland	1940	0.52	1	50	5	32.2
27	Camp Elliott, Cal.	1941	0.70	1	75	3	27.6
28	Camp Polk, La.	1941	2.1	1	103	3	38.4
29	Hill Field, Utah	1941	0.15	1	50	3	19.7
30	Wendover Bomb. Range, Utah	1941	0.17	1	25	3	18.9
	TWO-STAGE						
1	San Mateo, Cal.	1936	0.07	2	15	3	53.0
2	Healdsburg, Cal.	1937	0.4	2	36	3	85.7
3	Petaluma, Cal.	1938	1.0	2	75	3	30.0
4	Turlock, Cal.	1938	2.0	2	90	3	55.2
5	Covina, Cal.	1939	0.5	2	60	3	20.0
6	Santa Paula, Cal.	1939	1.0	2	80	3	35.1
7	Lakeport, Cal.	1939	0.25	2	36	3	46.0
8	Monterey County Hosp., Cal.	1939	0.05	2	20	3	25.0
9	Yountville Veterans Home, Cal.	1940	0.5	2	50	3	48.0
10	Auburn Cal.	1940	1.0	2	60	3	40.0
11	Liberty, N. Y.	1940	1.0	2	80	3	28.5
12	Chesterfield Co., Va.	1940	0.8	2	45	3	48.0
13	Prineville, Ore.	1940	0.15	2	30	3	17.7
14	Camp Haan, Cal.	1940	1.05	2	80	3	30.0
15	Plainview, Minn.	1940	0.33	2	54	3	43.4
16	Goldendale, Wash.	1940	0.75	2	36	3	49.4
17	Camp Livingston, La.	1940	2.0	3	67	3	54.0
18	Camp Stewart, Ga.	1940	2.0	2	73	3	63.7
19	Camp Wallace, Texas	1941	1.05	2	45	3	102.0
20	Camp Warren, Wyo.	1941	0.525	2	50	3	38.3
21	Camp Roberts, Cal.	1941	2.1	2	90	3	52.2
22	Camp Wolters, Texas	1941	1.26	2	69	3	55.2
23	Fort Sill, Okla.	1941	3.0	2	85	3	21.0
24	Naval Air Station, Seattle, Wash.	1941	0.35	2	36	3½	48.9
25	San Diego Housing, San Diego, Cal.	1941	1.20	2	80	3	34.0
	THREE-STAGE						
1	San Leandro, Cal.	1939	0.06	3	15	3	42.7

* To April 15, 1941.

Cannery, beet sugar, creamery, distillery wastes, etc. with very high B.O.D. can be effectively treated on Biofilters with much greater removals of B.O.D. than with weaker wastes, such as domestic sewage.

For instance, B.O.D. removals of 5.23 lb. per cu. yd. per day were obtained when treating beet sugar waste having a raw B.O.D. of 1650 p.p.m. Also, in the case of a distillery waste having a B.O.D. of 20,000 p.p.m., removals as high as 15.4 lb. per cu. yd. per day were obtained. The recommended B.O.D. loadings for 3 ft. depth filter are given in the following table:

Recommended Filter B.O.D. Loadings
3 Foot Depth Filter

B.O.D. of Raw Sewage	B.O.D. Removal in Filter Lb./Cu. Yd./Day
Less than 100 p.p.m.	0.8
100 p.p.m. to 150 p.p.m.	1.5
150 p.p.m. to 300 p.p.m.	2.0
300 p.p.m. to 450 p.p.m.	2.5
450 p.p.m. to 600 p.p.m.	3.0

Note: Where greater filter depths are employed, lower B.O.D. loadings should be used.

It will be noted that loadings increase as the strength of the waste increases.

Dosing rates on a filter appear to have little effect on the Biofilter operation, provided the dosing rate does not fall below 4 to 8 m.g.a.d. and does not exceed about 100 to 125 m.g.a.d. These high rates of application prevent the accumulation of solids in the filter bed, keep the surface wet more or less continuously thus preventing the propagation of filter flies, and result in a continuous unloading of solids from the filter. The maximum rate stated above should not be exceeded, as otherwise the filter bed will be flooded.

Three different flowsheets have been worked out to obtain various degrees of treatment. With the single-stage intermediate treatment an effluent having a quality between that of primary treatment and a standard trickling filter may be obtained. With normal strength of sewage having a 200 to 250 p.p.m. B.O.D., a reduction of about 50 to 60 per cent may be expected where the volum of recirculated flow is equal to at least twice the volume of the new sewage entering the plant. Figure 1 shows a typical flowsheet for a single-stage intermediate treatment.

Where overall B.O.D. reductions of 75 to 85 per cent are required, the single-stage complete treatment flowsheets shown in Fig. 2 are recommended. The results produced from this flowsheet should be on a par with standard trickling filters.

A two-stage complete treatment plant is shown in Fig. 3. This type of plant utilizes the primary Clarifier for the dual purpose of settling the raw sewage and the primary filter effluent, thus reducing plant cost by elimination of a separate intermediate settling tank. This flowsheet is especially adaptable where very strong sewages are encountered and when a high degree of treatment is required. With normal strength sewage and a recirculation ratio of 1.0 in each stage, this two-stage system should effect an overall reduction in B.O.D. of 95 per cent with the production of a well nitrified effluent, high in dissolved oxygen and low in suspended solids. In this respect, this flowsheet may be regarded as producing results having the full equivalent of the activated sludge process.

Typical plant results are shown in Tables 1, 2 and 3.

In connection with the Biofiltration System we have developed special types of two-arm and four-arm Distributors to operate at relatively low heads. Characteristic features of these units are the use of

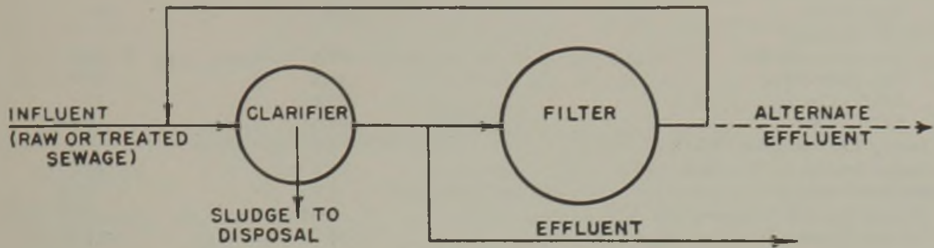
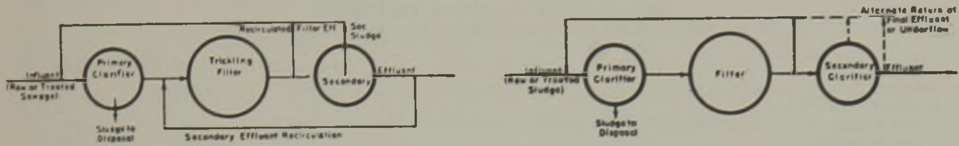


FIG. 1.—Single-stage intermediate treatment.



6A 6B

FIG. 2.—Single-stage complete treatment.

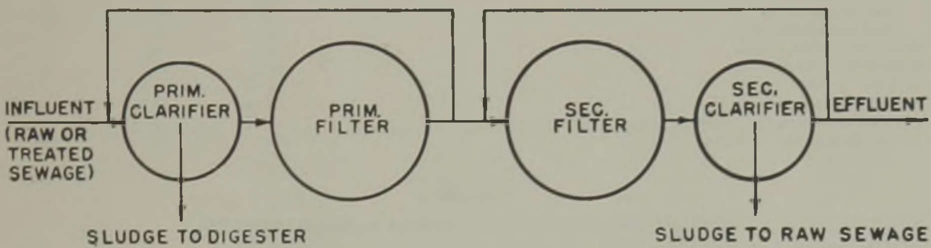


FIG. 3.—Two-stage complete treatment.

tapered arms having a box section with rounded corners and terminating in a true circular section at the end of the arms. Single compartment arms may be used where the head available is in excess of that required at maximum flow at a definite setting of the orifies or slots. When the flow fluctuations are considerable, say three to one, and it is desired to operate at low head, the arms have two compartments, one above the other, to take care of this condition. The bottom compartments are designed to handle any desired proportion of the maximum design flow, quantities in excess of this being taken by the top compartment.

TABLE 1

SINGLE-STAGE INTERMEDIATE TREATMENT — WEAK AND STRONG SEWAGE

Samples collected hourly over 24 hour periods and composited according to flow.

	Petaluma, Calif.	*Healdsburg, Calif.*
Test Period	5 days	5 days
Suspended Solids—ppm		
Raw Sewage	394	200
Clarifier Effluent	126	69
Filter Effluent	132	120
B.O.D.—ppm		
Raw Sewage	636	304
Clarifier Effluent	257	87
Filter Effluent	216	125
Per cent Removal		
Sus. Solids—Clarifier	68.0	65.5
Sus. Solids—Filter	66.5	40.0
B.O.D.—Clarifier	59.6	71.4
B.O.D.—Filter	66.0	58.9
Dosing Rate—M.G.A.D.—Raw	5.0	8.0
Dosing Rate—M.G.A.D.—Total	19.5	49.0
Recirculation Ratio	2.9	5.1
Average Raw B.O.D. Loading—Lbs. BOD/c.y./day	5.38	3.99
Clarifier Overflow Rate—Gals./sq. ft./24 hours	1170	1120

TABLE 2

SINGLE-STAGE COMPLETE TREATMENT

Samples Collected Hourly Over 24 Hour Periods and Composited According to Flow.

	Petaluma, Cal	*San Mateo, California*	
Test Period	5 days	4 Days	5 Days
Suspended Solids—P.P.M.			
Raw Sewage	437	201	233
Primary Effluent	167	157	80
Final Effluent	48	60	33
Primary Removal—Per cent	61.8	21.8	65.7
Total Removal—Per cent	89.0	70.1	85.8
B.O.D.—P.P.M.			
Raw Sewage	644	231	238
Primary Effluent	419	131	143
Final Effluent	53	45	16
Primary Removal—Per cent	35.0	43.3	40.0
Total Removal—Per cent	91.8	80.5	93.3
Dosing Rate—M.G.A.D.—Raw	4.9	19.0	10.2
Dosing Rate—M.G.A.D.—Total	17.2	69.5	38.4
Recirculation Ratio	2.50	2.65	2.76
Aver. Raw Loading—Lbs. B.O.D./c.y./day	5.35	7.57	4.17
Aver. Settled Loading—Lbs. B.O.D./c.y./day	3.48	4.30	2.50
Clarifier Overflow Rate—Gals./sq. ft./24 hrs.	1,095	3,130	1,730

TABLE 3

TWO-STAGE COMPLETE TREATMENT — PLANT RESULTS

Samples collected hourly over 24 hour periods and Composited according to flow.

	Petaluma, Calif.		*San Mateo, Calif.*		*Healdsburg, Calif.*
Test Period	5 days	7 days	5 days	4 days	7 days
Suspended Solids—ppm					
Raw Sewage	394	462	233	201	249
Primary Effluent	126	150	33	60	64
Final Effluent	38	43	30	17	29
Primary Removal—Per cent	68.0	67.5	85.8	70.2	74.3
Total Removal—Per cent	90.3	90.7	87.1	91.5	88.2
B.O.D.—ppm					
Raw Sewage—ppm	636	521	238	231	395
Primary Effluent	257	333	16	45	84
Final Effluent	33	28	13	13	27
Primary Removal—Per cent	59.6	36.0	93.2	80.5	78.7
Total Removal—Per cent	94.8	94.6	94.6	94.3	93.2
Dosing Rate—M.G.A.D.—Raw	5.0	10.6	10.2	19.0	7.90
Dosing Rate—M.G.A.D.—Total	19.5	37.1	38.4	69.4	49.0
Recirculation Ratio	2.90	2.50	2.76	2.65	5.19
Average Raw Loading—Lbs. BOD/c.y./day	2.69	4.78	2.08	3.78	2.53

Both types of Dorrco Distributors may be designed to operate at heads in the center column as low as 18 to 24 in. above the stone surface. In single compartment units adjustable rectangular slotted openings are along the side of the arms near the bottom. In the case of two-compartment arms, the openings are near the juncture of the campartments. A continuous spreader is located below the openings so that a continuous sheet of liquid is spread on the surface of the filter as the arms rotate. The height of the slots is so regulated that the average speed of the four-arm unit does not exceed 1.5 r.p.m., or the two-arm machine 3.0 r.p.m. Because of their lower cost, the two-arm units are preferred and should be used wherever practicable.

TABLE 4

RECOMMENDED RECIRCULATION RATIOS FOR VARIOUS STRENGTHS OF SEWAGE

B.O.D. — Raw Sewage	*Single-Stage Intermediate Treatment*	*Single-Stage Complete Treatment*	*Two-Stage Treatment (Each Stage)*
Up to 150 p.p.m.	1.0	0.75	0.5
150-300 p.p.m.	2.0	1.5	1.0
300-450 p.p.m.	3.0	2.25	1.5
450-600 p.p.m.	4.0	3.0	2.0
600-750 p.p.m.	5.0	3.75	2.5
750-900 p.p.m.	6.0	4.5	3.0

The above recirculation ratios are based on securing maximum overall performance for each type of plant. Lesser recirculation volumes may be used, but with proportional decrease in overall performance.

TABLE 5

BIOFILTRATION SYSTEM — CLARIFIER DESIGN

	Single-Stage Treatment		*Two-Stage*
Primary Clarifier	*Intermediate*	*Complete*	*Treatment*
Max. O'flow rate — gals./sq. ft./24 hrs.	800-1000	1200-1500	1200-1500
Min. Detention-Hrs.	2.0	1.5	1.5
Secondary Clarifier			
Max. O'flow rate — gals./sq. ft./24 hrs.	....	800-1000	1200-1500
Min. Detention-Hrs.	....	1.5	1.5

TABLE 6

COMPARISON OF TOTAL CONSTRUCTION COSTS OF VARIOUS TYPES OF PLANTS

Aver. Design Capacity-MGD	*Standard Trickling Filter per MGD*	*Single-Stage Complete Biofilter per MGD*	*Activated Sludge per MGD*	*Two-Stage Biofilter per MGD*
1.0	$120,000-150,000	$80,000-110,000	$90,000-120,000	$90,000-120,000
2.5	110,000-140,000	70,000-100,000	80,000-110,000	80,000-110,000
5.0	100,000-130,000	60,000- 90,000	70,000-100,000	70,000-100,000
10.0	90,000-120,000	50,000- 80,000	66,000- 90,000	60,000- 90,000

TABLE 7

DETAILED ESTIMATES — CONSTRUCTION COSTS* 1.0 M.G.D. PLANT

	Standard Trickling Filter	*Single-Stage Complete Biofilter*	*Activated Sludge*	*Two-Stage Biofilter*
Primary Clarifier	$ 6,650	$10,200	$ 6,650	$ 8,850
Filter or Aerator	41,500	8,300	12,800	9,050
Secondary Clarifier	5,750	5,750	7,150	8,850
Pumps, Blowers, etc.	560	2,310	3,600	3,400
Piping, Valves, Fittings	1,500	2,100	1,900	2,400
	$55,960	$28,660	$32,100	$32,550
Add 20% for Engineering, Contingencies, etc.	11,190	5,540	6,420	6,510
TOTAL	$67,150*	$34,200*	$38,520*	$39,060*

*Cost of screen and grit chambers, digesters, sludge drying facilities and buildings not included.

TABLE 8

COMPARISON OF OPERATING COSTS

Costs include fixed charges, labor, power, repairs, maintenance and supplies.

Design Flow M.G.D.	*Standard Trickling Filters per m.g.*	*Single-Stage Complete Biofilter per m.g.*	*Activated Sludge per m.g.*	*Two-Stage Biofilter per m.g.*
1.0	$40	$34	$60	$37
2.5	37	31	55	34
5.0	35	29	50	32
10.0	33	27	45	30

TABLE 9

ANNUAL OPERATING COST* ON 1.0 M.G.D. PLANTS

	Standard Trickling Filters	*Single-Stage Complete Biofilter*	*Activated Sludge*	*Two-Stage Biofilter*
Fixed Charges at 7½%	$5,030	$2,570	$2,890	$2,940
Power at 2¢/kw. hr.	—	490	2,920	890
Labor at $.50/man hr.	730	730	730	730
Supplies at 1½% of Equip. Costs	120	140	125	190
Maintenance & Repairs—2% of Equip. Costs	160	190	170	250
	$6,040*	$4,120*	$6,835*	$5,000*

*Operating costs for screening, grit removal, sludge drying and disposal not included.

TABLE 10

TWO-STAGE COMPLETE TREATMENT PLUS MAGNETITE FILTER

Liberty, New York — August 28-Sept. 5, 1940

Averages of daily 24 hr. composite samples

Test Period	7 days
Flows	
Maximum—M.G.D.	2.09
Minimum—M.G.D.	0.31
Average—M.G.D.	0.91
Suspended Solids	
Raw Influent—P.P.M.	160
Secondary Clarifier P.P.M.	26
Final Effluent—P.P.M.	10
Overall Removal—Percent	93.7
B.O.D.'s	
Raw Influent—P.P.M.	202
Secondary Clarifier P.P.M.	25
Final Effluent—P.P.M.	12
Overall Reduction—Percent	94.0
Turbidity	
Secondary Clarifier P.P.M.	8.1
Final Effluent—P.P.M.	4.6

Test Period	7 days
Dissolved Oxygen	
Final Effluent—P.P.M.	6.0
Clarifier Data	
Primary Clarifier	
Detention—hours	1.17
Overflow rate—gal. per sq. ft. per day	1426
Secondary Clarifier	
Detention—hours	1.58
Overflow rate—gal. per sq. ft. per day	1140
Biofiltration Data	
Filter dosing rate (each filter) raw—M.G./A/D	7.8
Filter dosing rate total—M.G./A/D	27.8
Recirculation ratio	2.56
B.O.D. Loading (both filters) Lbs. per cu. yd. per day	1.34

TABLE 11

TWO-STAGE BIOFILTRATION VERSUS STANDARD TRICKLING FILTER OPERATION LIBERTY, NEW YORK

Averages of Samples Collected Hourly, 8 A.M. to 2 P.M., and Composited According to Flow.

Test Period	*Two Stage Biofiltration System* 9 days	*Single Stage Standard Filter Operation (no recirculation)* 12 days
Flow—Aver. M.G.D.	0.70	0.70
Suspended Solids		
Raw Influent—P.P.M.	215	228
Primary Effluent—P.P.M.	60	90
Secondary Effluent—P.P.M.	8.5	21.3
Filter Effluent—P.P.M.	1.3	—

Test Period	*Two Stage Biofiltration System* 9 days	*Single Stage Standard Filter Operation (no recirculation)* 12 days
B.O.D.'s		
Raw Sewage—P.P.M.	360	342
Primary Effluent—P.P.M.	111	192
Secondary Effluent—P.P.M.	12.6	42.9
Filter Effluent—P.P.M.	4.9	—

Note: In the second portion of these tests, the two stage biofilter plant was changed over temporarily to a standard single stage trickling filter operation with the shallow biofilter depth of 3 ft. Note the comparative data, favoring Biofiltration, and also the relatively good showing of standard trickling filter operation, even with a shallow bed depth.

In the Biofilter System, we recommend a propeller type of pump for recirculating filter effluent, which is used extensively in irrigation work and manufactured by a number of companies. This type of pump has relatively high efficiencies at low head and is made in sizes from 8 to 36 in. with normal capacities of 500 to 40,000 g.p.m. in the low head range. Where smaller pumping capacities are required, any of the standard vertical open impeller centrifugal pumps should be applicable. Normally, with a 3 ft. filter depth, the recirculation pump will be pumping at an 8 to 10 ft. head, correspondingly greater heads being required with the deeper beds. Recommended recirculation ratios are shown in Table 4.

Clarifiers in Biofilter plants should be rated on overflow rates as well as on detention periods. The former is by far the more important factor. Table 5 shows the preferred base of design for the various types of plants. Both overflow rates and detention should be based on the total flow to the Clarifiers, including the recirculated flow. In general, within limits, the greater the recirculation ratio, the higher are the overflow rates, the lower are the detention periods that may be used without adversely affecting results.

Tables 6 to 9 show the comparison of total construction and operating costs of various types of plants. Complete plant costs may differ widely due to local conditions, etc. In any case, however, it appears that single-stage Biofiltration will cost about $30,000 to $40,000 per million gallons less than standard filter plants, while two-stage Biofiltration will cost about the same as a complete activated sludge plant, all comparisons being based on identical capacities. Some more recent figures on Army Camp construction indicate that these figures are very high, but it must also be considered that sewage treatment plants for Army Camps lack the expensive buildings and equipment usually found in municipal plants.

The Biofilter System is flexible in design and operation, and consequently can be adapted to various applications. It can be used for treating domestic sewage and trade wastes ranging from low to high B.O.D.'s. Removals of B.O.D. may be varied from, say 50 to 95 per cent, depending upon requirements. It is applicable to improving existing sewage treatment plants which are overloaded, pretreatment of industrial wastes before entering city sewers, to take care of seasonal loads such as at summer or winter resorts, etc. For more complete information on the Biofiltration System, please refer to the article by A. J. Fischer and R. B. Thompson on "The Biofiltration Process of Sewage Treatment," *Municipal Sanitation,* November, 1939, and the article by A. J. Fischer on "The Biofiltration System," reprinted in *Water Works and Sewerage,* October, 1940.

Table 12 shows comparison of data on filter depths.

It is interesting to note that up to date, April 15, 1941, 56 installations of Biofilter plants are operating or under construction. These plants are located all over the country, with the majority of the installations being in the State of California, where the process was developed. The Biofilter plant at Liberty, New York, is the first one to be installed in New York State. This plant has been operating less than a year, but some operating data are available to give the indications as to what the plant will do. As you know, Liberty is a summer resort having a winter population of 3,500 and a summer population of 13,000 people. During the summer months, the additional population, two laundries, two milk receiving stations and a packinghouse add a

TABLE 12.—*Single-Stage Biofilter Test Results—Comparison of Filter Depths*

	Test 1	Test 2	Test 3
Filter Depth	6 ft.	4 ft.	2 ft.
Raw Dosing Rate—M.G.A.D.	12.0	12.0	12.0
Total Dosing Rate—M.G.A.D.	60.0	60.0	60.0
Recirculation Ratio	4.0	4.0	4.0
Suspended Solids—P.P.M.			
Raw Sewage	315	293	288
Primary Clar. Effluent	160	133	147
Final Clar. Effluent	46	58	57
Primary Removal—Per cent	49.3	54.6	49.0
Total Removal—Per cent	85.4	80.2	80.2
B.O.D.'s—P.P.M.			
Raw Sewage	233	268	273
Primary Clar. Effluent	165	205	179
Final Clar. Effluent	63	52	67
Primary Removal—Per cent	29.2	23.5	34.5
Total Removal—Per cent	83.0	80.6	75.5
Raw Loading Lbs. B.O.D./c.y./day	2.40	4.15	8.45
Dissolved Oxygen—Final Effl.	4.5	4.0	2.9

tremendous load of B.O.D. to this plant. The plant was put into operation late in the season of 1940, and consequently complete operating data are not available during the maximum loading conditions of the plant. In the winter time, the filters are operated as low rate standard filters and operating data have been obtained during the past year by Harry Eichenauer, Plant Chemist. The results obtained by him are shown in Tables 10 and 11. It will be noted that the raw sewage was sampled from 8:00 A.M. to 2:00 P.M., and the final Clarifier effluent from 9:00 A.M. to 3:00 P.M. This period of sampling represented the strong day flow, and it is concluded that if the filters will handle this strong sewage during the daytime, the effluent will be satisfactory during the balance of the day when weaker sewage is received. It is proposed to obtain further data during this summer with the plant close to its maximum loading.

Conclusion

In conclusion, it may be stated that Biofiltration and other high-rate filters have done much to promote the progress of sewage treatment and to reduce the cost of plant structures and operating costs. Much still remains to be learned relative to the underlying principles of high-rate filters. Since high-rate filters have now been demonstrated quite broadly, activated sludge, which has been so popular for the past few years, has more or less lost its popularity.

A DISCUSSION OF HIGH–CAPACITY TRICKLING FILTERS, WITH SPECIAL REFERENCE TO AERO–FILTERS *

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A number of failures have been reported in high-capacity filter installations. These failures can invariably be traced to a lack of understanding of the requirements for such filters either on the part of the designers or the operators. If designed and operated correctly all three types of high-capacity filters will perform satisfactorily—yes, even better than many persons believed possible. If the results from correctly designed and operated high-capacity filters are compared with those of even the best of the standard filters, their high degree of efficiency in reducing B.O.D. will stand revealed. It is to the advantage of every town, engineer, operator, and manufacturer of equipment, that failures in this new type of filter be eliminated. For this reason we shall set forth pertinent data concerning these filters which will serve not only as a means of classifying the various types of trickling filters, but will also show that each has its own design requirements.

In a trickling filter the B.O.D. is removed by bringing the organic content of the sewage into contact with the flora on the rock, in the presence of an abundance of oxygen. In practice the new types of trickling filters accomplish this in one of two ways. Either the sewage is given one pass through the filter and the distribution is so regulated that the sewage flows over the rock in a thin, continuous film; or the sewage is recirculated a number of times, the distribution being such that the flow over the rock is relatively heavy. These schemes are equally effective if the plant design provides uniform and light application in the first case and adequate recirculation in the second, and if it provides clarifiers of sufficient size in each case to insure adequate settling time.

Levine, prior to 1930, showed that in the operation of standard filters rest periods of more than 2½ minutes reduced the filter efficiency. He observed that with 2½ minute rest period the filter discharged at almost a constant uniform rate, whereas the discharge became less and less uniform as the rest periods increased. He also noted that the reduction in the 5-day B.O.D. improved as the rest period was shortened, but he did not note improvement with a rest period of less than 2½ minutes. He therefore concluded that standard filters should be rested 2½ minutes. In actual plant operation this would, of course, be difficult to maintain without the use of a return system during a portion of the 24-hour day.

* Presented at the Spring Meeting of the New York State Sewage Works Association, Niagara Falls, June 19–21, 1941.

In his experimental work he employed the tip-trough method of dosing the filter; hence for all practical purposes we could say the dosing period was about one-half minute and the rest period 2½ minutes. In applying 3 m.g.a.d., a total of 240 minutes would thus be used in dosing, and 1200 minutes in resting. In other words, the dosing rate would amount to $\frac{3 \text{ m.g.a.d.}}{240 \text{ (min.)}} = 12{,}500$ gallons per acre per minute.

Halvorson conceived the idea that by continuous and uniform momentary dosing the filter capacity could be greatly increased. If the filter is dosed at a constant rate of 12,500 g.p.m., the 24-hour rate equals 18 m.g.a.d., which the average daily capacity now used and recommended for Aero-filters.

When Dr. Halvorson made his studies of the trickling filter he found that purification could be achieved more effectively if the sewage were distributed over the rock in a very thin film, and that high capacities could be handled if this film were kept flowing continuously over the surfaces of the rock in all sections of the bed. Even with high capacities, if the sewage is distributed evenly over the bed at all times the amount which strikes any square foot area during any second of time is very small. That is, the rate of application is actually very low.

The term "rate of application" has long been used in sewage treatment discussions, notably in the expression "m.g.a.d." However, this expression tells us nothing about how or during what time the sewage is applied, merely giving the volume in bulk per day. In essence, m.g.a.d. merely expresses capacity. When our attention was turned to the effectiveness of uniform distribution of sewage over the filter bed, "rate of application" took on additional meaning. It now is used to indicate how the sewage is being spread over the filter surface by expressing the amount that falls upon a square foot during a definite interval of time, usually a second. To avoid misunderstanding it seems best to use the term "capacity" to designate the total daily flow of sewage in gallons per acre, and to use the term "rate of application" to tell us how much sewage is applied per square foot momentarily or during a second of time. Filters may then be discussed and compared in two respects, that of total daily raw sewage flow and that of the methods used for distribution and the rates at which the sewage falls on various sections of the filter bed.

Any two filters with the same capacity may differ materially in the rate at which the sewage is applied. Let us assume that two standard filters are each handling 3 million gallons of sewage in 24 hours with the same size of filter bed. Suppose that one operates on a 20-minute rest cycle, the other on a 5-minute cycle. It is apparent that a greater volume of sewage must be applied in operating cycles having a 20-minute rest period than with those with a 5-minute rest period. The flow down through the media must be heavier with the 20-minute rest period. The longer the rest period, the higher the rate of momentary application at points of contact, other conditions being the same.

Or let us assume that the same two filters are operating without rest periods but that one is fitted with a centrally located means of distribution which sprays the sewage evenly over every quare foot of filter surface every second of the day and night. Further, let us suppose that the other filter is fitted with a two-arm distributor rotating at ½ to 1 r.p.m. and is applying sewage momentarily to 1 or 2 per cent of the total bed area. Clearly a much heavier flow of sewage must fall on the 1 or 2 per cent of the bed than when it is momentarily spread evenly over the entire surface. That is, the rate of application with the two-arm rotary distributor might easily be from fifty to several hundred times as high as with the centrally located distributor.

This distinction between rate and capacity enables us to classify and compare the various types of trickling filters which have been developed so far, as is shown in the following diagram.

Trickling Filters

- Type A — Low Daily Capacity, High Rate, Standard Filters. 3500 to 5000 pop. equivalent per acre foot, or 300 to 400 pounds of B.O.D. per acre foot.
- High Daily Capacity
  - High Rate (Heavy Recirculation) (Heavy Momentary Distribution)
    - Type B — Recirculation of filter effluent through Primary Clarifier.
      - *"Bio-filter"* U.S. Patent No. 2,168,208
    - Type C — Recirculation of clarified filter effluent back to the filter.
      - *Non-patented* Recirculation from final clarifier back to a head box located between the filter and the clarifier preceding said filter.
      - *"Accelo Filter"* U.S. Patent No. 2,097,779 Recirculation from final clarifier directly to distributor column in the filter.
  - Low Rate (Light Recirculation) (Light Momentary Distribution)
    - Type D — Recirculation of clarified filter effluent back directly to inlet of the filter, but only during periods of low raw sewage flow in sufficient quantity to maintain a minimum of 10 to 13 m.g.a.d. on the filter.
      - *"Aero-filter"* U.S. Patent No. 2,141,979

Types A, B and C use the same method of distribution, that is 2, 3 or 4-arm distributors rotating from ½ to 1 r.p.m. Fixed nozzles are used in some installations. Such distributors produce a high rate of application, relatively large quantities of sewage being applied to the areas being momentarily dosed and finding their way down through the restricted sections of the bed beneath. The fourth Type D, the Aero-filter, normally uses disc distributors for filters 34 ft. or less in diameter, and multiple-arm distributors operating from 2 to 3 r.p.m. on larger beds. Obviously the rate of application when discs are used is low since the sewage is sprayed over all the bed at all times. The multiple-arm rotary distributors used with Type D filters also give a much lower rate than that developed by 2, 3 or 4-arm distributors rotating slowly. There would be only three applications per minute on a given filter radius even with a 4-arm distributor operating at ¾ r.p.m.

This is one of two 70 ft. diameter Aero-filters operating in parallel at Camp Bowie, Brownwood, Texas. Maximum rate of flow to each filter 3.5 m.g.d. Average plant capacity 1.5 m.g.d. per filter.

This filter was operating at 2000 g.p.m. and the distributor was held in a fixed position when the photograph was made, hence the scalloped appearance of the inside of the wall.

In contrast the number of arms and branches on an Aero-filter distributor are such in each size that there are always many more than 20 applications per minute. For example a 70-ft. diameter Aero-filter has a distributor with 10 trunk arms and 20 branched arms with the distributor rotating at approximately 2 r.p.m. at low flows and 3 r.p.m. at maximum flows. The longest arc between the ends of any two consecutive arms of an Aero-filter distributor is not more than 16 feet.

Ideal distribution is obtained when every square foot of filter surface receives momentarily an application of sewage equal to that received by every other square foot. Obviously this is the lowest uniform rate possible with a filter for any selected size and capacity. A 34 ft. filter with a capacity of 375,000 gal. daily is used as a basis for comparing the rates developed with different methods of distribution.

It is evident that the momentary rate of application on areas being dosed, developed in ideal distribution, is far lower than those rates obtained in Filters A, B and C. Naturally Types A, B and C could reduce their rates either by increasing the number of arms or by increasing the speed of the distributor, or by doing both. However, this would automatically change them into Type D, the Aero-filter.

34' dia. Filters: 375,000 G.P.D. (18 M.G.A.D. average flow) - 4.3 G.P.S.

Aero-filter
Disc Distributor

Continual, complete, approximately uniform coverage. Approaches ideal distribution.

$\frac{Q}{A \times T}$ = Ideal Rate of Application

$\frac{4.3}{908 \times 1}$ = .0046 Gal. per sq.ft. per sec.

Aero-filter
4 arms, 8 branches
Rotary Distributor

Approximately 20% momentary coverage by centrifugal nozzles when held stationary. Rotation 4 R.P.M. 32 contacts per minute on a given radius.

$\frac{Q}{A \times T}$ = Rate of Application when held stationary.

$\frac{4.3}{\frac{908}{5} \times 1}$ = .023 Gal. per sq.ft. per sec.*

High Momentary Rate
2-arm Rotary Distributor

Approximately 2% coverage when held stationary. Rotation 1 R.P.M. 2 contacts per minute on a given radius.

$\frac{Q}{A \times T}$ = Rate of Application when held stationary.

$\frac{4.3}{\frac{908}{50} \times 1}$ = .23 Gal. per sq. ft. per sec.*

Q = G.P.S. T = Seconds A = Sq. ft.

*Since the 4-arm distributor rotates at 3 R.P.M. its actual rate of application is much lower than shown. Since the 2-arm distributor rotates at 1/2 to 1 R.P.M. its rate is somewhat lower than .23 gal. per sq. ft. per second, but its increase over the rate of the 4-arm distributor is 8 to 24 times that shown.

As the rate on the filter is increased the volume of sewage passing down through any section of the filter being dosed becomes greater and a stream rather than a thin film flows over the rock media. The bacteria then do not have access to a high percentage of the oxidizable materials and the sewage must be recirculated enough times to provide the flora with an opportunity to complete their work. With Types B and C it is found necessary to recirculate through the filter several times.

In a recent publication a graph was used to show that when neither recirculation nor low rate of application was used, 12.5 cu. ft. of rock were required per pound of B.O.D. applied to the filter to effect a reduction of 44 per cent in the 5-day B.O.D. through the filter and final clarifier. Type D filters using a low rate of application are giving reductions of 47 per cent with only 4½ cu. ft. of filter media per pound of B.O.D. Efficiencies comparable to those of Type D can be expected from properly designed B and C types.

As the rate is reduced per square foot of area per second for a given capacity the amount of recirculation needed diminishes. Type D, the Aero-filter, operates with a rate of application far below that used with even Type A filter; hence recirculation is not required even for high capacities. Sufficient amounts are recirculated during periods of low flow to maintain operation between 10 and 15 m.g.a.d. or at ½ the maximum peak rate of several hours.

The statement that no parallel recirculation is used with Type D (Aero-filter) applies to sewage with B.O.D.'s of less than 400 to 450 p.p.m. As the strength of the raw sewage increases, so too does the filter area, if the depth is kept constant, in order to provide a sufficient volume of filtering media. A few simple calculations will show that finally the area becomes so great that some return must be made at all times in order to maintain approximately a 10 to 15 m.g.a.d. minimum rate upon the filter. In other words, the minimum rate of 10 to 15 m.g.a.d. upon the filter becomes greater than the volume of raw sewage flow.

We have already shown that the momentary rate on the Aero-filter at point of application is not more than one-tenth that of types B and C. This being the case, for a given strength of sewage, a 1:1 recirculation ratio on types B and C result in a much higher B.O.D. momentary load at point of application than would be applied in Type D filters without recirculation.

From the foregoing explanations it is evident that Types B and C are much alike, but that they differ fundamentally from Type D in the method by which they produce reductions in B.O.D., the former being high-capacity, high-rate filters, the latter being a high-capacity, low-rate filter. Each has its specific requirements in design, and failure will result if these requirements are not met.

Revamping Standard Filters

The capacity of a standard filter can be increased by making use of recirculation, by eliminating rest periods or by reducing the rate of application and thus improving the distribution. However, if Type A is converted into either of the Types B, C or D certain factors must be taken into consideration. As the capacity of the filter is increased, larger filtering material, up to a maximum of from 2½ to 4 inches in diameter, should be provided. This larger material will provide larger voids between the stones to accommodate the increased amount of sewage, sludge and air that must be handled in high-capacity filters. Since for Types B and C recirculation must be used in parallel with the raw sewage flow, it is also necessary to provide the proper sizes of pumps and settling tanks through which recirculation is to be made. In the case of Type D, the clarifiers do not have to be increased but the distributor must be changed to provide much better momentary distribution than is used on standard filters.

Single-Stage vs. Two-Stage Filters

With a given quantity of filtering material, higher percentages of B.O.D. reduction can be obtained by dividing the aggregate between two filters and employing stage operation than by placing all of it in one filter and using single-stage operation.

Filters of Types A, B, C and D all use a primary and final clarifier in combination with one or more filters operating in parallel for single-stage operation. Type B filter uses two filters and a primary and final clarifier in two-stage operation. An intermediate clarifier may also be employed between the two filter stages which makes it possible to pass all of the sewage through both filters and all three clarifiers. In Type B, recirculation is carried on through both the primary and final clarifiers with two-stage operation. Therefore, in two-stage operation both clarifiers should be constructed to take care of the combined flow of recirculated and raw sewage.

Types C and D filters use a primary and a final clarifier in combination with one or more filters in parallel for single-stage operation, but in two-stage plants an intermediate clarifier is installed between the first and second-stage filters. Recirculation is practiced through the intermediate and final clarifiers; hence, in two-stage operation these two clarifiers must be constructed to take care of the combined flow of raw and recirculated sewage. The Aero-filter, or Type D, does not use recirculation except during periods of minimum raw-sewage flow and

Table I.—*Minimum Recirculation for Various Strengths of Sewage * as Recommended on Page 481, October, 1940, Issue of Water Works and Sewerage*

Raw Sewage B.O.D., p.p.m.	Recirculation		† Factors to be Used in Determining the Size of Clarifier When Parallel Recirculation is Used (Types B and C Filters)	
	Single Stage	Two Stage	Single Stage	Two Stage
Up to 150	0.75	0.5	1.75	1.5
150 – 300	1.5	1.0	2.5	2.0
300 – 450	2.25	1.5	3.25	2.5
450 – 600	3.0	2.0	4.0	3.0
600 – 750	3.75	2.5	4.75	3.5
750 – 900	4.5	3.0	5.5	4.0

For example: With a raw sewage B.O.D. of 150 to 300, high-capacity, high-rate filters (Types B and C) require 1.5 of recirculation to 1 of raw sewage in single-stage operation. Therefore, the size of the clarifier through which recirculation is carried on must be 2½ times that which is required if no recirculation were being used. In two-stage operation, based on 150 to 300 p.p.m. of B.O.D., one part of recirculation is paralleled with one part of raw sewage. Therefore, the clarifiers through which recirculation is carried on must be twice the size they would be if no recirculation were used.

In the case of Type D (Aero-filters) the size of the clarifier is based on the rate of flow of raw sewage, without recirculation, unless the B.O.D. if raw sewage is in excess of 450 p.p.m. 5-day B.O.D.

* *Waterworks and Sewerage*, October, 1940, page 481.

† Not given in published table.

then only in sufficient amounts to keep the filter operating at about half of its maximum design flow, hence the sizes of clarifiers are not increased as they are with Types B and C.

Clarifiers

The relationships between the strength of the raw sewage, amount of recirculation necessary for single and two-stage operation with Types B and C, and the sizes of the clarifiers through which recirculation is conducted, based on volume of flow, are given in the following tables. The size of clarifiers used with Aero-filters is determined by the flow of sewage through the filter or filters, no allowance being necessary for recirculation, unless the sewage strength is in excess of 450 p.p.m. 5-day B.O.D.

Table II.—*Clarifiers Recommended for High Capacity Aero-filters*

	At Average Flow	Several Hours Peak Flows	
Primary			
Overflow Rate, Max. gals./sq.ft./24 hours	650	1200	
Detention Time, Hours	2.5	1.5	
Intermediate			
(Two Stage)			
Overflow Rate, Max. gals./sq.ft./24 hours	1000	1800	1500 } Preferably
Detention Time, Hours	1.5	.75	1. } Preferably
Final			
Overflow Rate, Max. gals./sq.ft./24 hours	650	1000	
Detention Time, Hours	2.5	1.5	

Sizes are based on total flow through clarifiers which includes raw sewage plus necessary parallel recirculation.

Experience has shown that the size of the final clarifier used with high-capacity filters is as important as the size of the primary clarifier because high-capacity filter sludge is fine and light. In my opinion, each should be based on the total flow to be handled by them whether this be only raw sewage or a combination of raw and recirculated sewage. The intermediate clarifier used with two-stage filters may be based on two-thirds of the final tank requirements. Greater emphasis should be placed on the overflow rate rather than the detention time.

Filter Areas and Filter Depths

In general, relatively deep, narrow filters are better for Aero-filter operation than wide shallow filters, because the flow to the filter is based on the raw sewage and not on a combined flow of raw and recirculated sewage. Furthermore, the deep narrow filter is less costly to construct than a wide shallow filter having the same quantity of filtering material. Aero-filters, like other types of high-capacity filters, may be constructed of any desirable depth; however, we do not recommend less than 5 ft. of depth for single-stage operation, and never less than 3 ft. for two-stage operation. Maximum depths of 8 ft. are recommended. In two-stage operation when a total combined depth of more than 6 ft. is necessary for the two filters, we believe it is preferable, where the hydraulics will permit, to put the greater portion of the filtering material in the first-stage filter and to use the second stage more or less as a polishing filter.

A single filter 8 ft. deep will not give as good results as two filters, each of the same area but only 4 ft. deep, provided in the latter case a settling tank is used between the filters. On the other hand, for the same area, a filter 6, 7 or 8 ft. deep will give a better B.O.D. reduction than one 4 ft. deep. In other words, the deeper the filter up to certain limits, the better will be the plant effluent. Reductions in B.O.D. of course do not bear a direct relationship to filter depths.

When deciding whether to design for single-stage, relatively deep filters (7 to 8 ft.), or two-stage, shallow filters (4 to 5 ft.), various factors must be taken into consideration, each presenting a different problem. For example, the degree of treatment required and the ultimate cost of producing the necessary results must be considered. It is less costly to pump sewage once through a filter 6 ft. deep than through two filters in series 3 ft. deep. The increase in the operating cost is due to the double pumping head required for two distributors as compared with the head for one.

Table III shows the relationship between population equivalent per acre foot and filter areas required for several depths of filter beds per each 1000 population.

TABLE III

Population Equivalent Per Acre Foot	Square Feet of Filter Area for Various Depth Media Required for Each 1000 Population, Based on Population Equivalent Per Acre Foot Shown in Left Hand Column					
	Depth of Filter in Feet					
	8	7	6	5	4	3
40,000	136.1	155.8	181.5	217.8	272.2	363.0
*35,000	155.5	177.7	207.3	248.8	311.	414.7
†30,000	181.4	207.3	242.	290.2	362.8	483.7
25,000	217.8	248.9	290.4	348.4	435.6	580.8
20,000	272.2	311.1	363.	435.5	544.4	725.9
15,000	363.	415.	484.	580.8	726.	968.
10,000	544.4	622.2	726.	871.	1088.8	1451.7
‡5,000	1088.8	1244.3	1452.	1742.1	2177.6	2903.5
§4,000	1361.	1555.	1814.	2177.	2722.	3629.
3,000	1814.	2073.	2418.	2902.	3628.	4837.
2,000	2722.	3111.	3646.	4375.	5444.	7259.

* Loading allowed by U. S. Army in warm climates for high capacity filters.
† Loading allowed by U. S. Army in northern climates for high capacity filters.
‡ Loading allowed by U. S. Army in warm climates for standard filters.
§ Loading allowed by U. S. Army in northern climates for standard filters.
The U. S. army figures 70 gallons per capita per day average flow, with 0.17 lb. 5-day B.O.D. per capita per day.

Filter Loadings—B.O.D. and M.G.A.D.

It is not unusual to figure the sizes of high-capacity filters on the basis of 3.5 lb. 5-day B.O.D in the raw sewage per cubic yard of filtering material. Of course, the loading actually applied to the filter will depend upon the B.O.D. reduction obtained through pre-treatment, if any, and primary clarification. If we use the figure 3.5 and allow for 35 per cent removal of the B.O.D. before the sewage is applied to the filter, we have 2.278 lb. B.O.D. per cu. yd. of rock or 3675 lb. per acre foot. The U. S. Army figures .17 lb. B.O.D. per capita. Table IV shows the lb. of B.O.D. applied per acre foot of filter based on given populations equivalent, .17 lb. B.O.D. per capita, and different percentages of reduction in the B.O.D. obtained through primary clarification.

Table IV

Population Equivalent Per Acre Foot	Pounds B.O.D. Raw Sewage	Percentage B.O.D. Reduction Through Primary Clarification			
		35	40	45	50
		Pounds of B.O.D. Applied to Filters Per Acre Foot After the Above Reductions in the Primary Tank			
40,000	6800	4420	4080	3740	3400
*35,000	5950	3867	3570	3273	2975
*30,000	5100	3315	3060	2805	2550
25,000	4250	2762	2550	2337	2125
20,000	3400	2210	2040	1870	1700
15,000	2550	1657	1530	1402	1275
10,000	1700	1105	1020	935	850
*5,000	850	552	510	467	425
*4,000	680	442	408	374	340
3,000	510	331	306	280	255
2,000	340	221	204	187	170

* U. S. Army.

Artificial Ventilation

It is generally admitted that an abundance of air in a trickling filter is necessary. Ventilating fans may be used to assist in supplying the air during certain seasons of the year when conditions are not favorable for sufficient natural ventilation.

Certainly fans would be of little benefit on filters four feet and less in depth, but for deeper Aero-filters their use is recommended. The cost of installing and operating fans to pull one cu. ft. of air per sq. ft. of filter area per minute down through the filter is almost negligible. The underdrain system of high capacity filters should be designed to insure plenty of air capacity. Full block tile bottoms are recommended.

Results

High capacity filters will give results in B.O.D. reductions commensurate with those of standard filters if they have been designed properly and are operated correctly. Numbers of Aero-filter plants bear out this statement. In general, when especially high purification is required on raw sewage having a 5-day B.O.D. of less than 450 p.p.m., we recommend either two-stage operation, or single stage followed by sand filters, to obtain from 88 to 98 per cent reduction. In the case of stronger sewages two stages are recommended. Single-stage filters will produce satisfactory results in most cases where domestic sewage is to be handled or where a purification of 84 to 94 per cent is sufficient.

Aero-Filters—Webster City, Iowa

Two-Stage

This plant has two Aero-filters each 40 ft. in diameter by 7.75 ft. deep. The sewage is a combination of domestic and industrial waste plus storm water. The piping is so arranged that the filters can be operated in stage during dry weather and in parallel during storm periods.

The following results are expressed on a 24-hour rate basis.

Date	B.O.D., p.p.m.			Percentage B.O.D. Red.		Pounds of B.O.D. Applied to Filters				Air Temp.	
	Raw	To Filter	Final Effl.	Through Plant	By Means of 1st Filter	Square Foot	Acre Foot	Cubic Foot	Cubic Yard	Max.	Min.
June, 1940	248	100									
1st filter.....			30	88	70	.32	1780	.041	1.1	—	—
2nd filter.....			25	90	75	.095	522	.012	.36	—	—
Oct. 7, 1940	288	162									
1st filter.....			53	82	67	.46	2620	.060	1.62		
2nd filter.....			20	93	87	.15	870	.020	.54	64	40
Oct. 15, 1940	305	122									
1st filter.....			31	89	74	.35	1960	.045	1.21		
2nd filter.....			23	92	81	.089	480	.011	.33	57	30
Oct. 23, 1940	310	109									
1st filter.....			24	93	78	.31	1740	.055	1.08		
2nd filter.....			15	97	86	.089	480	.011	.33	68	39
Nov. 24, 1940	273	148									
1st filter.....			15	94	89	.42	2396	.055	1.48	41	20
Dec. 9, 1940	417	275									
1st filter.....			59	86	75	.79*	4530*	.104*	2.8*	50	30
Dec. 23, 1940	340	260									
1st filter.....			73	79	72	.61	2400	.078	2.1	47	30

* *Overloaded.*—Rating is 2.275 pounds per cubic yard of rock.

The average rate of application 15 m.g.a.d. Only sufficient return is used to maintain the minimum required flow. No return is used for dilution purposes.

Mason, Michigan—Single Stage

There are two 30 ft. diameter Aero-filters with disc distributors built for parallel single stage operation. The entire flow is being handled by one filter.

Results for June, July, August and September, 1940

	Flow					Suspended Solids			B.O.D., p.p.m.		
	Raw		Return		Percentage Return						
	M.G.D.	M.G.A.D.	M.G.D.	M.G.A.D.		Raw	Effl.	% Red.	Raw	Effl.	% Red.
Max.	.718	44.2	.153	9.42		250	56		212	40	
Min.	.202	12.5	.001	.06		94	10		83	1	
Av.	.355	21.9	.035	2.15	10	165	27	83.5	125	14	89

Filter media is glass slag 2½ inches by 4 inches in diameter.
Monthly B.O.D. results taken from 12 hour daytime composite.
Samples averaging seven days per month.

Rosenberg, Texas.—Single Stage Aero-filter 28 ft. diameter. Disc Distributor.

Primary Clarifier, rectangular
- Area, sq. ft. 441
- Volume, cu. ft. 3,750

Final Clarifier, rectangular
- Area, sq. ft. 468
- Volume, cu. ft. 3,744

Aero-filter
- Diameter, ft. 28
- Depth, ft. 8
- Total cu. yd. of rock 182
- Lakeside Distributor, 1½ H.P. motor-driven disc

Flow

The raw sewage is lifted from the raw sewage wet well (bottom elevation 72.85 to the primary clarifier (W.L. 99.75), from whence the flow is by gravity through the single stage Aero-filter and final clarifier.

All Sampling Volumetrically Composited

Date	Sampling Hrs.	B.O.D., p.p.m.			Suspended Solids, p.p.m.			Dissolved O., p.p.m.	
		Raw	Final Eff.	% Red.	Raw	Final Eff.	% Red.	Raw	Final Eff.
11–29–40	8 A.M. to 6 P.M.	160	12	92.6	200	6	97	2.4	7.0
11–30–40	7 A.M. to 6 P.M.	213	53	75	324	34	89.6	0.5	3.6
12–6–40	24 hours	160	32	80	174	16	90.8	0.0	2.4
12–7–40	9 A.M. to 6 P.M.	180	28	84.4	350	28	92	1.2	4.6
12–7–40	24 hours	210	40	81	266	38	85.7	0.0	2.4
12–8–40	8 A.M. to 5 P.M.	320	36	88.7	468	36	92	0.0	4.6
	Average	207	33	84	297	26.3	91.	.7	5.1

Single Stage Aero-Filter, Temple, Texas

This filter was designed to handle an average flow of 1.35 m.g.d. and a peak rate of 2 m.g.d. The rock used was out of an old standard filter and it is smaller than should be used in Aero-filters. The filter is 61 ft. in diameter and 8 ft. deep. The plant has gravity flow with return pumping during periods of low raw sewage flow.

Total flow of sewage from June 1, 1940, to June 1, 1941, 593.4 m.g., or 1.62 m.g.d. Total cost of power for all purposes $275.40, or $0.43 per m.g. This shows the small return requirements of a properly designed Aero-filter plant.

Date April 1941	Raw Sewage Average, m.g.d.	5 Day B.O.D., p.p.m.			D.O. Final Effl.
		Raw Sewage	Final Effl.**	Stream Below Plant*	
3	2.17	227	20	9	5.6
7	3.05	253	22	9	2.2
10	1.86	380	20	10	4.2
14	1.62	68	28	14	.4
21	1.53	100	5	5	5.8
27	2.27	132	20	18	3.8
30	2.43	64	29	8	4.2
Average	2.42	175	20	10.4	3.75
B.O.D. reduction	88.5%				

* Sample below plant is a grab sample but others are composited.

** When the flow of sewage exceeds 2 m.g.d., the primary effluent is by-passed around the filter to the entrance of the final clarifier.

Above data were obtained from the plant operator, and Mr. N. E. Trostle, Water Superintendent and City Engineer of Temple.

Conclusion

In order to obtain satisfactory results from high-capacity filter installations, one should select the type of plant he proposes to use, whether it be type B, C or D, and then design to meet the requirements of that particular type. Several failures have resulted from attempts to use the Aero-filter design with a distribution such as is used on Types B and C.

Close attention should be given the recirculation requirement, as it may affect the sizes of the recirculation pumps and the sizes of the clarifiers.

THE ACCELO–FILTER *

By H. W. Gillard

International Filter Co., 325 W. 25th Place, Chicago, Ill.

Operation experience with the biological filter has proven it to be perhaps the most dependable of secondary sewage treatment devices. It has demonstrated ability to handle excessive varitions of organic or hydraulic loads with no more than temporary falling off of purification results and usually without permanent impairment of the filter efficiency.

Sir Edward Frankland's [1] laboratory experiments in 1868, as published in the first report of the British Rivers Pollution Commission, were no doubt the forerunner of the present day trickling filter although Dr. Alexander Mueller [2] had previously shown that sewage purification could be obtained by means of micro-organisms. The Lawrence experiment station of the Massachusetts State Board of Health [3] in 1887 confirmed the work of Frankland, working with sand filter media and using intermittent dosage. A desire for higher application rates and the elimination of troublesome clogging led to experiment with coarser media filters at Lawrence in 1889. The work of Dunbar,[4] Corbett,[5] Stoddard [6] and others, together with the work at the Lawrence station, definitely established the trickling filter as a dependable secondary sewage treatment device in the early 1890's. In general these early filters were operated at rather low dosage rates although Corbett reported dosage rates of 7 m.g.a.d. in 1902. During 1906 Imhoff [7] reported the filter at Naumburg, Germany, operated at rates as high as 20 m.g.a.d. during periods of storm flow. Others reported filter loading rates varying from 6 to 10 m.g.a.d. during the period from 1906 to 1928. About this time Chas. H. Shock, convinced that the conventional trickling filter could be successfully operated at increased dosage rates, provided suitable scientific controls were incorporated in plant design, started work that led to a demonstration plant.

In spite of published evidence of successful high rate application, tricking filter designs were conservatively held to 1.5 to 3.0 m.g.a.d. depending on organic loading, probably due to influence of the results obtained from operating installations. A study by Childs and Schroepfer [8] in 1931 of 15 typical filter plants in the United States, some of which were being operated at high loading rates both organic and hydraulic, seems to have been the impetus of independent work by Levine, Halvorson, Jenks and others, all apparently searching for means of assured successful biological filter operation at increased application rates. The Childs-Schroepfer report indicated the per cent reduction in 5-day B.O.D. of a filter was not greatly influenced by either sewage strength or filter application rates.

* Presented at the Spring Meeting of the New York State Sewage Works Association, Niagara Falls, June 19–21, 1941.

If we consider what we actually know about the mechanism of the biological oxidation processes, we reach the conclusion that there must be two factors of prime importance. One is the establishment and maintenance of a biological growth on the filter media. The other is time of contact of the sewage to be treated with that biological growth or film. Now the time of contact will not be greatly reduced at the higher application rate and we have ample evidence to support the fact that a healthy biological filter flora can be developed and maintained at these high application rates.

Many conventional trickling filters demonstrate that high application rates upwards of 150 m.g.a.d. are experienced at times of maximum head and discharge (*i.e.* at high liquor level in the siphon chamber). Under this condition each fixed nozzle doses only an annular ring about 10 in. wide, while a rotary distributor under the same maximum head condition doses only a 10 in. wide strip, the length obviously equal to the total length of the distributor arms. Present general acceptance of the fact that applied sewage moves through the filter media in a more or less vertical direction with practically no coning, furnishes added evidence that high application rates have actually been demonstrated by most conventional filters in service.

With recirculation of filter effluent in a well activated condition, the added contact time should be logically expected to enhance purification results to at least equal those of a conventional biological filter dosed at the so called standard application rate. Moreover, the higher dosage rate if properly applied will provide sufficient flushing action to prevent excess accumulations of solids or humus in the interstices of the filter media. Also the continuous inoculation of sewage by the recirculation of activated material must have a beneficial effect on the biological oxidation process.

The importance of adequate ventilation of the entire filter bed and underdrain system is now understood and appreciated by all sanitary engineers. Undoubtedly some of the few reported filters providing unsatisfactory results can be attributed to this one factor, particularly among earlier installations, when effluent underdrains were not available and smaller filter media was used. Most of us have seen some of these filters with the underdrain system completely flooded during peak or storm flow periods, when only the upper portion of the bed was obtaining aeration from the bed surface. Undoubtedly some of these unfortunate installations have been responsible for retarding the general acceptance of higher filter loading rates. Even with operation under such adverse conditions these plants produced fairly good results.

It must be conceded that all of the so-called high rate or high capacity filters are simply our old friend the biological or trickling filter including recirculation with perhaps a few additional improvements in drainage and ventilation. There can be little doubt that some flocculation occurs in the operation of any biological filter. Dr. Mohlman [9] has reported that a filter dosed at high rates seems to function as a biological flocculator which removes colloidal and soluble material. It will be appreciated that adequate final sedimentation must be considered essential to proper operation of any high rate filter.

The Accelo-Filter system, with its unique controlled direct recirculation feature providing inoculation of an aerobic process with a previously aerated well activated material, provides accelerated biological oxidation of a settled sewage or industrial waste. High filter loading rates may be used with the assurance of freedom from nuisances such as odors and psychoda flies. Continuous filter operation at practically constant discharge rate is provided by the automatic control of recirculation pumps which maintain an almost constant head on the distribution device. Average sewage purification results at least equal to those of the conventional filter can be obtained with a single stage installation.

We know that a single passage of settled sewage through a biological filter will result in a substantial reduction in the organic content of that sewage. Certainly additional passages under conditions of proper aerobic activation will provide additional reduction. This then may be said to be the basic principle of the Accelo-Filter. Its value is being demonstrated in actual practice.

Although the advantages of this system are obvious, it may be well to list them for emphasis. They are:

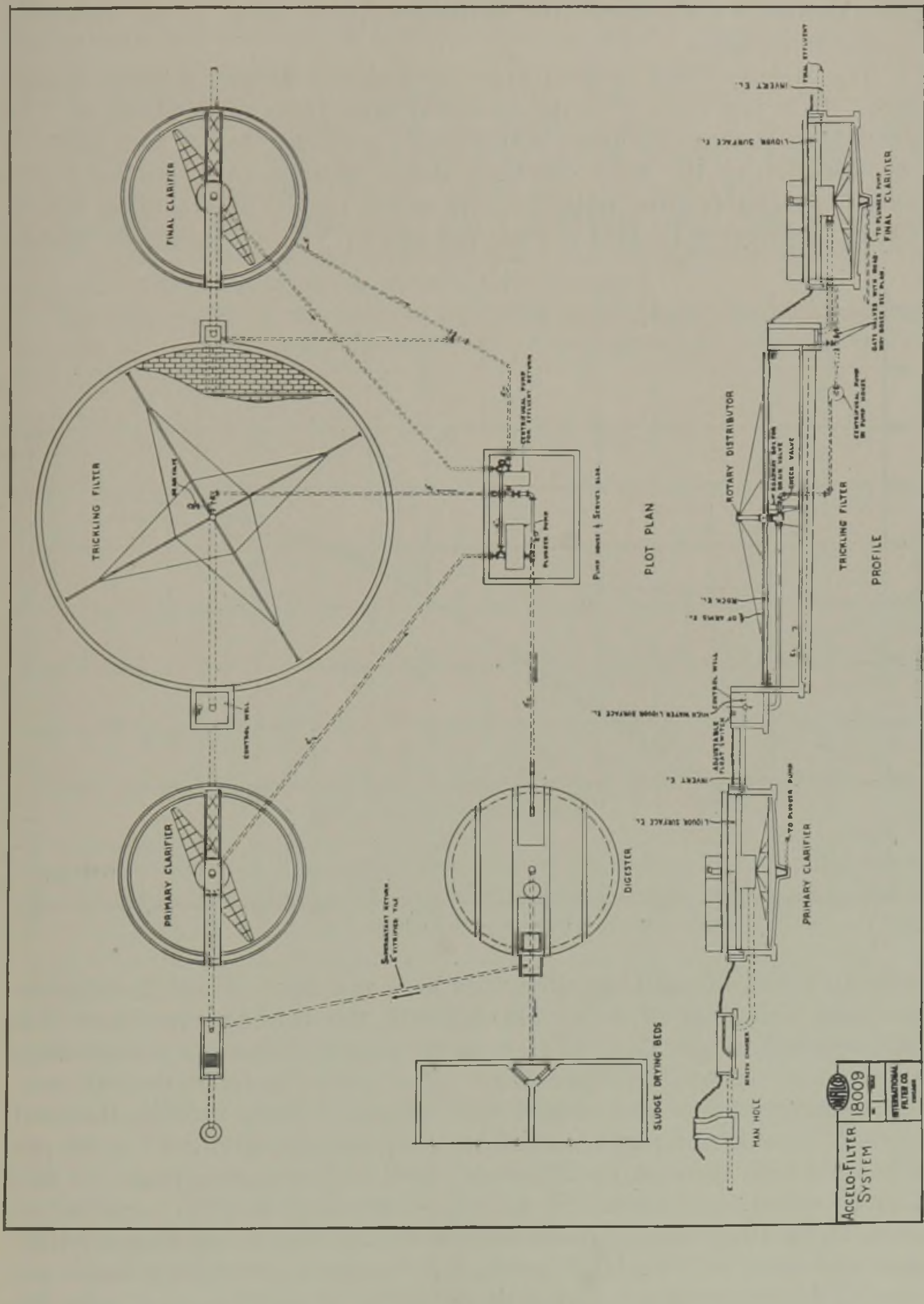
1. Savings in initial investment made possible by use of higher application rates on a smaller filter.
2. Odor nuisances caused by anaerobic decomposition of accumulated humus within the filter are eliminated.
3. Continuous filter operation seems to keep the psychoda fly nuisance greatly abated.
4. Filter clogging is eliminated by the continuous removal of excess bacterial gel accumulations from the filter.
5. Settled sewage reaching the filter is continuously inoculated with aerobic life.
6. The circulating material is continuously reactivated by aeration.

Material may be recirculated from the filter effluent conduit, the final clarifier or the final clarifier effluent launder. Thus either settled sludge from the final clarifier, clarified effluent or a mixture of the two are available for direct recirculation.

Design Data

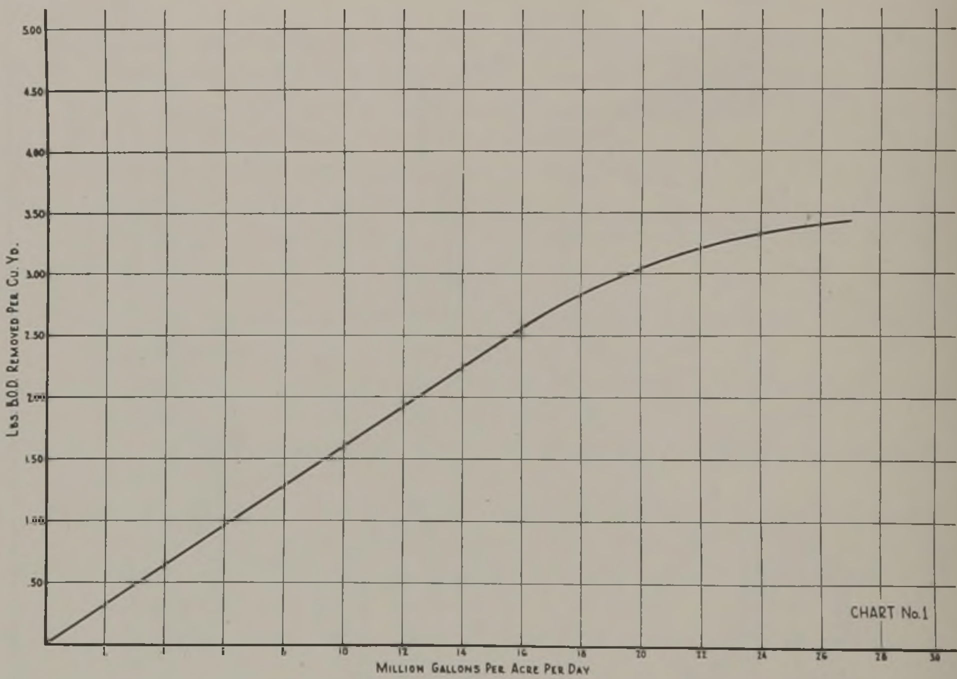
Primary Sedimentation.—The primary sedimentation tank need be no larger than that required for a conventional trickling filter. For normal domestic sewage a displacement period of 1½ to 2½ hours seems to be indicated by current practice. It will be appreciated that sewage having a relatively high concentration of settleable solids may require longer detention periods.

Accelo-Filter.—The most rational method of determining the size of a biological oxidation filter would seem to be on a basis of lb. B.O.D.


FINAL CLARIFIER
TRICKLING FILTER
PRIMARY CLARIFIER
CONTROL WELL
DIGESTER
SLUDGE DRYING BEDS
PLOT PLAN
ROTARY DISTRIBUTOR
TRICKLING FILTER
PROFILE
PRIMARY CLARIFIER
FINAL CLARIFIER
MAN HOLE
ACCELO-FILTER SYSTEM
18009

removed per unit volume of filter media. However, the loading in terms of hydraulic flow rate per unit of filter area must be considered because proper flushing action is essential. Another point vital to the filter design is the amenability of the sewage or waste to the biological oxidation process.

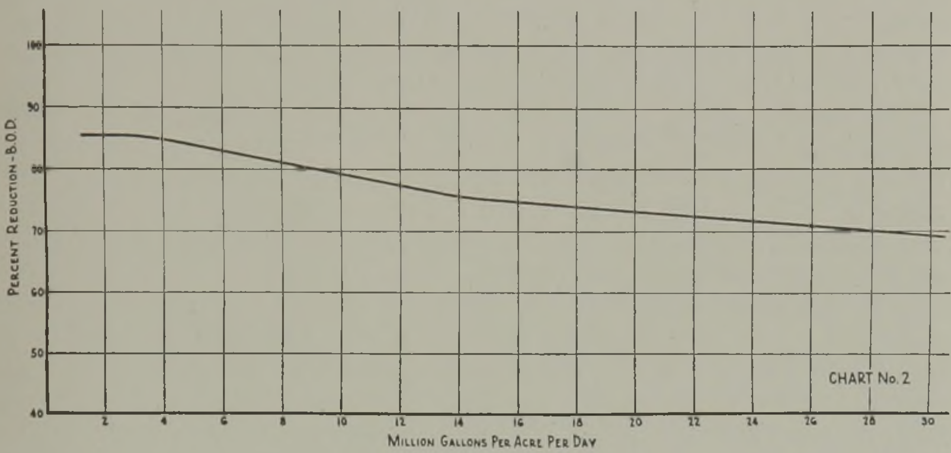
The Accelo-Filter system may be designed at any desired dosage rate. It is not limited to the so-called high rates of application. To provide designing engineers with actual experience to use as a guide in the selection of the most desirable design dosage rate—we have prepared two charts from published operation results of biological filters. Chart 1 compares lb. B.O.D. removed per cu. yd. of media with dosage



rates in terms of million gallons per acre per day. Chart 2 compares per cent reduction of 5-day B.O.D. with the loading rate in million gallons per acre per day. These curves simply indicate a conservative estimate of reasonable expectation. The points were plotted by comparing filter influent with settled filter effluent. These indicate the most efficient filter loading to be about 10 to 15 m.g.a.d., giving 75 to 80 per cent reduction through the filter and final sedimentation tank. It will also be noted that 1.5 to 2.8 lb. B.O.D. removal may be expected at these application rates. Recirculation should assure additional reduction and adequate flushing action. A conservative design basis for normal domestic sewage would therefore be 10 to 12 m.g.a.d. with 100 per cent recirculation, giving an actual filter dosage rate of 20 to 24 m.g.a.d. Higher organic loads may be provided for by increasing the recirculation rate, keeping the actual filter dosage rate at about 20 m.g.a.d. to insure adequate flushing.

The filter media should be clean, hard, durable crushed stone or gravel 3 in. to 4½ in. in size, that will not disintegrate due to action of the sewage or weather. Slightly smaller sizes are permissible in the second stage of a two stage filter. The media should be 5 to 6 ft. in depth although depth as shallow as 3 ft. may be used if local plant topography and available head conditions permit. If shallow filter depths are used increased filter area should be provided based on the media quantity indicated by lb. B.O.D. removed per cubic yard. The greater depth media will prove more desirable from both the standpoint of initial investment and operation if a suitable underdrain system that will provide sufficient ventilation is used.

To insure better ventilation than the underdrain tile available afforded, we developed a reinforced concrete block mold. By the use of



this mold the installing contractor can manufacture underdrain blocks at the treatment plant site. This underdrain system provides ample area for both aeration and ventilation as well as the sewage flow. There is now available an Armore type AA vitrified tile underdrain that will provide the desired increased flow and ventilation area. Both the reinforced concrete and the vitrified tile underdrains are designed to provide horizontal ventilation in two directions. To insure cleansing velocities a minimum filter bottom gradient of 0.5 per cent is recommended. When there is plenty of available head a greater slope may be used. An effluent channel across one diameter of the filter bed should likewise be provided with a gradient that will provide cleansing velocities. This channel should preferably be open to the atmosphere at both ends as a means of further improving aeration of the filter.

The distribution device must be selected to handle the average sewage flow rate plus the recirculated material. During periods of maximum flows the control chamber adjustable float switch limits the operation of the recirculation pumps so that the head on the distributor may be maintained within the desired limits. It is obvious that the distributor must be designed for the maximum discharge rate. It will be appreciated therefore that an existing trickling filter designed for dosage on a conventional basis cannot be used for these high application rates without extensive changes to the distributor mechanism and possibly the underdrain system.

Each arm of the distributor for the Accelo-Filter is equipped with aero-spray nozzles spaced for optimum radial distribution and desirable aeration of the sewage over the filter bed. The nozzle spacing is calculated to compensate for head losses due to friction as well as for head increase due to centrifugal force caused by rotation. The speed of the distributor and the radial coverage of each nozzle can be controlled by an adjustable deflector plate in front of each nozzle. This plate is held in position by a spring and stop so that temporary moving for cleaning will not disturb the permanent adjustment. This adjustment need only be made during initial operation since the head on each nozzle will be maintained within close limits, unless a change in the distributor discharge rate is made necessary by a change in sewage flow rate or organic content of the sewage.

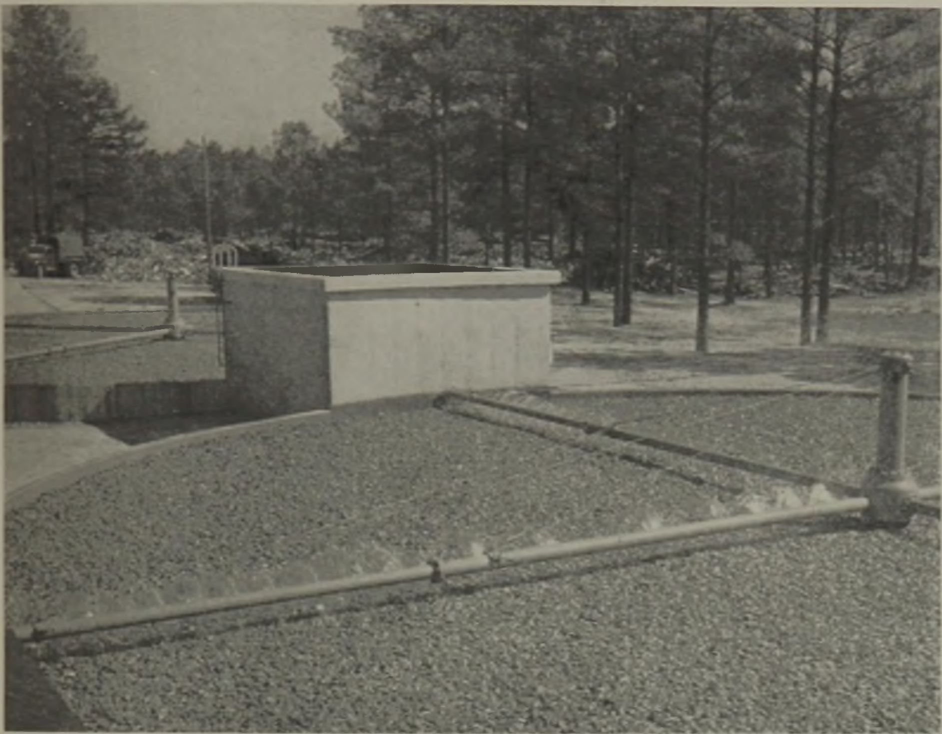
To make certain that adequate flushing and washing of the filter media is obtained, the rotation speed of the distributor mechanism is limited and two arm distributors are preferred. The speed of a 2-arm machine is limited to 2 r.p.m., and a 4-arm machine to 1.4 r.p.m. By this means clogging and ponding are prevented and mechanical wear on the equipment is greatly reduced.

Obvious benefits are derived from the direct recirculation system and the control features of the Accelo-Filter. Although the filter may be designed for dosage to accommodate any rate of incoming sewage flow or combined incoming sewage and recirculated flow, the actual filter dosage rate must be selected to provide adequate treatment to the applied organic load. Several passages of sewage through the filter may be necessary for adequate treatment of sewage or waste having a high organic content or limited available effluent dilution.

Final Sedimentation.—A final sedimentation tank is essential to proper operation of the Accelo-Filter system because excess biological gel is continuously washed from the filter media. The displacement period of this tank will of course depend on the quantity and method of recirculation employed. It is recommended that not less than two hours retention, based on the average sewage flow rate plus recirculated material, be used for the design of this tank. Thus when any material is recirculated from the filter effluent, the displacement time will be increased and if only final clarifier effluent is recirculated the displacement period will be at least two hours.

Accelo-Filter plants in service, both the original demonstration unit and subsequent installations, offer convincing proof of the efficiency of the system. Continuous operation coupled with direct recirculation are proving the absence of odors and psychoda fly nuisances. The psychoda are only seen at such times as the filter distributors are temporarily taken out of service. When the filter is dosed continuously very few psychoda are in evidence. The demonstration plant treating settled sewage to which lime had been added for pH adjustment, using an actual filter dosage rate of slightly more than 10 m.g.a.d. obtained a B.O.D. reduction of 92.4 per cent and a suspended solids removal of 96.8 per cent.

An Accelo-Filter installation at Fort Jackson, Columbia, S. C., is producing a well clarified effluent with no difficulties from psychoda flies or odors. This plant is using a filter dosage rate of 10 m.g.a.d. based



Accelo-Filters, Fort Jackson, Columbia, S. C.

on average sewage flow rates with 100 per cent direct recirculation, making the actual filter dosage rate 20 m.g.a.d. Another plant has recently been placed in service at Ellington Field, Genoa, Texas. Several other projects that will include the unique Accelo-Filter principle of direct recirculation are in process of design or construction. Although no analytical data are available from Ft. Jackson or Ellington Field at this time, we are told that the apparatus needed to conduct the necessary tests will be made available to the operators so that we may expect such information soon. Visual observation of the filters at Fort Jackson, the surfaces of which are now that nice green color that is indicative of ample aeration and activation, furnish evidence of the development and maintenance of a well activated filter growth at the higher application rates. The settled effluent from this plant is clear and odorless.

A new method of increasing the efficiency of the well known sturdy biological filter by direct recirculation of filter effluent, clarified filter effluent, final clarifier sludge or a mixture of the three, is thus available to the designing engineer. Inoculation with the freshly aerated ma-

Ellington Field, Genoa, Texas.

terial together with repeated passages of sewage through a biological filter under the most favorable aerobic conditions provides increased reduction in organic content. The higher filter dosage rates provide washing and flushing sufficient to prevent undesirable accumulations of bacterial growth in the interstices of the filter media. If as indicated by the history of sewage treatment design, future plants are to be largely influenced by successful precedent, here is a logical method of securing greater efficiency from the sturdiest of biological oxidation processes.

Bibliography

1. Edward Frankland, First Report British Rivers Pollution Commission (1868).
2. Alexander Mueller, *Bulletin* 26, Illinois State Water Survey, A. M. Buswell (1928).
3. Massachusetts State Board of Health Special Report Purification of Water and Sewage, 1890.
4. W. P. Dunbar, *Principles of Sewage Treatment* (1908).
5. J. A. Corbett, "A Dozen Years of Sewage Purification Experiments on a Large Scale at Salford, England," *Engineering News* (1903). *Bulletin* 26, Illinois State Water Survey (1928).
6. Wallis F. Stoddard, see *Bulletin* 26, Illinois State Water Survey (1928).
7. Karl Imhoff, *Die biologische Abwasser-Reinigung*, 1906. Page 28–29. Table I.
8. J. A. Childs and George J. Schroepfer, "Trickling Filter Loadings," *Civil Engineering*, 1391 (December, 1931).
9. F. W. Mohlman, "Experimental High Rate Filters," *This Journal*, 8, 911 (Nov., 1936).

THE DETERMINATION OF GREASE IN SEWAGE, SLUDGE AND SCUM *

II. DETERMINATION OF GREASE IN SEWAGE

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The customary procedure in analyzing sewage for grease (1) has consisted of evaporating an acidified liter sample on a water bath, transferring the dry matter to an extraction shell and extracting with a common solvent. This method has been time-consuming and subject to error, particularly because of the small weight of the grease extracted from a one-liter sample. Larger samples could be handled but the evaporation procedure became too long drawn out for practical purposes. Even when larger samples were used, discrepancies of large magnitude occurred between duplicate analyses, which could not be explained on the basis of sampling error.

In considering the development of an improved method we chose to investigate methods of separating the solids from the sewage by other means than evaporation, rather than attempting to discover the factors causing difficulty in the evaporation method. We felt that if the lengthy evaporating step could be eliminated the new method would be of more value.

The most obvious method of separating the solids from the liquid is filtration. Filtration of several liters of sewage through any filter sufficiently fine to clarify the sewage is practically as time-consuming as evaporation and the question remained whether the clear filtrate was entirely free of lipoidal matter.

Experimental

A series of experiments were made involving different types of filter media. Filtrations which gave a clean filtrate were generally very slow. When the filtrate was completely clear, practically no grease was found in it. In general those which filtered with sufficient rapidity failed to remove all the suspended solids from the liquor. The most successful filter medium was a layer of filter paper in a Buchner funnel with a filter aid such as ''Dicalite'' or ''Filter-cel.'' In order to obtain the desired results, however, too large a quantity of the filter aid was necessary. The large bulk of filter aid required a very large extraction shell and prevented complete extraction in normal periods of extraction.

One important fact was brought out by this work, namely that in domestic sewage practically all the grease is in the suspended state.

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Aid of W.P.A.

Clear filtrates were evaporated, acidified and extracted and in no case was any appreciable amount of grease found.

It is a well known fact that chemical treatment of sewage removes practically all the grease from sewage. Ferric chloride, a common sewage coagulant, has long been known as a useful reagent in the determination of grease from boiler waters (1). With these facts in mind separation of the suspended solids from the liquor by precipitation with ferric chloride, followed by filtration through filter paper in a Buchner funnel, was tried. Preliminary trials showed that ferric chloride alone did not always give complete clarity even when the optimum dosage was applied. A more satisfactory method of assuring complete precipitation of the suspended matter was found to be the addition of lime water prior to the ferric chloride. When the pH was raised to about pH 9.0 with lime water, and 41 mgm. of ferric chloride per liter were applied, every sample of sewage with which we worked clarified completely. It was also found that a thin layer (2 mm.) of filter aid placed on the filter paper greatly accelerated the filtration. The following procedure was followed: A four-liter sample of sewage was poured in a beaker of five-liter capacity. Sufficient lime water was added to raise the pH to 9.0 and the sample was thoroughly mixed, followed by 41 p.p.m. of ferric chloride in solution form, added with constant stirring. Slow stirring was continued for ten minutes and thereafter the sample was allowed to stand to allow settling. A Buchner funnel 11.5 cm. in diameter was prepared by placing in it a Whatman No. 1 filter paper over a muslin filter cloth. Over this mat a slurry of filter aid containing 1 gram of the dry material was poured and the vacuum turned on. The mat was washed with one liter of distilled water, after which it was ready for use. When the sewage solids had settled to the bottom of beaker the clear liquor was decanted and passed through the filter. The settled solids were then poured in the funnel and filtration was continued until no more water drained off. The beaker was washed with distilled water and the washings put on the filter. When the mat was dry it was removed, placed in a small evaporating dish, acidified with 10 ml. of 10 per cent hydrochloric acid and dried at 60° C. When dry, the mat was transferred to a paper shell and extracted with petrolic ether in a Soxhlet apparatus for 12 hours, in the same manner used for the determination of grease in sludges, as described in the first paper of this series (2).

Results

Analyses were made in triplicate on eight samples of sewage. The results of these determinations are shown in Table I. It is noted that the three analyses of each sample fell within a maximum deviation of ± 5 p.p.m. from the average.

The average deviation was found to be ± 2 p.p.m., which demonstrates the comparatively high degree of agreement obtainable between analyses by this method.

Table I.—*Triplicate Analysis of Sewage Sludge for Total Grease by the Ferric Chloride-Lime Precipitation Method*

Sewage Sample Analyzed	P.p.m. Total Grease			
	1	2	3	Avg.
Plainfield	49	43	46	46
New Brunswick	54	56	55	55
Highland Park	46	46	49	47
South River	71	66	74	70
South River	83	84	78	82
South River	92	96	90	93
South River	71	76	80	76
South River	99	100	104	101

Ash and total nitrogen determinations were made on the grease extracted from these samples. Ash was determined on the extract from one of the triplicate analyses and the nitrogen on the combination of the other two. The ash and nitrogen are calculated in p.p.m. on the basis of the sewage. These figures for all samples are shown in Table II. The nitrogen content of all but one of the samples was nil. In the one sample in which it was present the amount was negligible. The quantity of ash found, however, was of consequence. Ten p.p.m. was found in the extract from one sample and the average of the eight samples was 5.0 p.p.m. These residues were analyzed and found to consist mainly of iron oxide. The source of iron we believed to be the ferric chloride used as coagulant in the method.

Table II.—*Ash and Nitrogen Content of Grease Extracted from Sewage Samples Treated by the Ferric Chloride-Lime Method*

Sample	P.p.m. Ash	P.p.m. Nitrogen
1	7	0
2	4	0
3	5	0
4	6	0
5	4	0
6	10	0.5
7	2	0
8	3	0
Avg.	5	—

In order to overcome this difficulty a change in coagulant was indicated. Alum was selected as having the best properties for our purpose. Triplicate analyses of 28 samples of sewage were made using the alum as the precipitating agent. The analysis was made on four-liter samples and the technique was the same as employed in the ferric chloride-lime precipitation, with the exception that 25 mgm. of aluminum per liter of sewage was the precipitating agent. This was added in solution form with constant stirring.

The triplicate analyses for grease are presented in Table III. Ash and nitrogen were determined on ten of the extracted residues. Inspection of these data reveals that the precipitation method employing alum yielded excellent checks between separate analyses on the same sample. The greatest deviation from the mean value observed for any of the sewages analysed was ± 7 p.p.m. while the average deviation in grease found for the entire twenty-eight sewages was ± 1.5 p.p.m.

TABLE III.—*Triplicate Analyses of Sewages by New Precipitation Method*

Source of Sewage Sample	Parts per Million Grease			
	1	2	3	Avg.
South River (Monday) (1)	151	157	153	154
South River (Tuesday) (2)	92	93	97	94
South River (Wednesday) (3)	112	108	110	110
South River (Thursday) (4)	78	79	73	77
South River (Friday) (5)	67	64	61	64
South River (Saturday) (6)	67	62	70	66
South River (7)	71	76	80	76
South River (8)	86	90	84	87
South River (9)	99	100	104	101
Plainfield (1)	44	47	41	44
Plainfield (2)	31	31	36	33
New Brunswick (1)	54	55	56	55
Highland Park	46	45	49	47
Highland Park	66	61	70	66
Sayreville	105	105	105	105
Middlesex	91	88	88	89
Elizabeth (1)	64	62	63	63
Rahway (1)	54	56	58	56
Morristown (1)	131	131	136	133
Morristown (2)	180	173	178	177
Raritan	256	251	256	254
Somerville	108	106	106	107
Bernardsville	244	254	247	248
Hillsdale	169	170	169	169
Bound Brook	129	132	131	131
New Brunswick (2)	45	46	45	45
Elizabeth (2)	150	162	153	155
Rahway (2)	99	98	97	98

That the ash content of the extracted matter was considerably lower when alum was used for precipitation than when ferric chloride and lime were used, is brought out by the figures in Table IV. The average ash content was only 1.0 p.p.m. on the sewage basis and the highest value was 3.0 p.p.m. The average amounts to only one-fifth of the quantity found when iron and lime were used for precipitating the solids. Nitrogen was absent in the extracted matter of all samples, indicating that alum is the superior precipitation method.

TABLE IV.—*Ash and Nitrogen Content of Grease Extracted from Sewage Samples Treated by the Alum Method*

Sample	P.p.m. Ash	P.p.m. Nitrogen
1	1.0	0
2	1.0	0
3	1.0	0
4	1.0	0
5	3.0	0
6	0.4	0
7	1.0	0
8	0.3	0
9	0.7	0
10	0.6	0
Avg.	1.0	0

Clear filtrates of sewage obtained after alum precipitation were examined for grease by evaporating two liters to dryness, acidifying, and extracting with petrolic ether. These tests were made to determine if the alum precipitation and filtration separated the grease from the liquor completely.

The amount of grease extracted from the clear filtrates of six sewages is given in Table V, together with the total grease content of the corresponding sample. It can be seen that the amount of grease recovered from the filtrates averaged only 3 p.p.m. The loss of grease through the filter is therefore not serious.

TABLE V.—*Grease Found in Filtrates of Alum-Coagulated Sewage by Evaporation Method*

Sewage Sample	P.p.m. Grease in Sewage	P.p.m. Grease in Coagulated Filtrate	Per Cent of Total in Filtrate
South River	90	2	2.2
Hillsdale	169	7	4.4
Elizabeth	63	0	0.0
Rahway	99	1	1.0
Somerville	107	4	3.7
Raritan	256	4	0.5
Average	131	3	2.3

Ten separate samples of raw sewage were collected from six different plants and the grease content and suspended solids determined by the alum precipitation method. Portions of each sample were allowed to settle for two hours. Samples of the settled sewage were then withdrawn, analysed for grease and suspended solids and the percentages of grease in the settled solids calculated. These results were compared with the average percentage of grease found in the fresh solids collected from the settling tanks at the corresponding plants. The comparison given in Table VI shows the agreement between the results. In other words, the amount of grease removed from the liquor

TABLE VI.—*Percentage Grease in Settled Solids as Found by Analysis of Raw and Settled Sewage by Alum Precipitation Method, Compared to that Found by Analysis of the Sludge from Plant*

Sewage Sample	Susp. Solids, P.p.m.			Grease, P.p.m.			Per Cent Grease in Settled Solids	Per Cent Grease in Fresh Solids from Plant
	Raw Sewage	Settled Sewage	Dif.	Raw Sewage	Settled Sewage	Dif.		
South River (1)	388	128	260	154	81	73	28.1	28.9
South River (2)	292	116	176	90	38	52	29.5	28.9
South River (3)	386	132	254	128	55	73	28.8	28.9
South River (4)	278	126	152	80	38	42	29.6	28.9
Sayreville	142	82	60	55	33	22	35.5	33.7
Elizabeth	454	94	360	155	53	102	28.4	25.3
Bernardsville	734	156	578	248	104	144	25.0	19.4
Morristown	568	94	474	177	66	111	23.5	25.2
Rahway (1)	259	90	169	98	43	55	32.5	23.9
Rahway (2)	164	52	112	65	35	30	26.8	23.9
Ave.	367	107	260	125	55	70	27.0	26.7

by settling the sewage as measured by the alum precipitation method checked that found in the sludge analysed by the method presented in the first paper of this series (2).

For comparison of the evaporation and alum precipitation methods thirteen samples of sewage were analysed for total grease. The analytical data presented in Table VII shows that the variation in results obtained by the two methods are not all in one direction. Some samples

TABLE VII.—*Comparison of Evaporation and Alum Precipitation Methods for Grease in Sewage*

Sewage Sample	Parts per Million Grease		Difference
	Evaporation	Precipitation	
Sayreville	56	54	− 2
Sayreville (Monday)	185	178	− 7
Rahway	54	56	+ 2
Plainfield	142	136	− 6
South River	230	218	−12
Middlesex	74	89	+15
Highland Park	62	66	+ 4
Morristown	142	133	− 9
Bound Brook	135	131	− 4
New Brunswick	38	45	+ 7
Rahway	95	98	+ 3
Somerville	96	107	+11
Raritan	226	254	+28

gave higher results by the evaporation method, others by the precipitation method. Agreement between the two methods was in general fairly good, the average variation being less than 10 per cent.

Discussion

A method of determining the grease content of sewage was developed which eliminated some of the errors and time loss experienced with the present evaporation method. The new method eliminates the evaporation entirely, thus saving time, cutting down the amount of manipulation, and eliminating losses of grease which may occur during evaporation (3). It allows the use of a large sample, thus reducing the error in weighing the extracted matter.

Alum was found to be superior to ferric chloride and lime as a precipitating agent. Extracts following its use contained practically no ash and were free of nitrogen. Little loss of grease occurred by the precipitation and filtration as shown by the filtrates containing an average of about 3 p.p.m. grease. This loss is compensated by the ash content of the extracted grease, which averages 2 p.p.m.

This method yielded results which were remarkably reproducible. Triplicate analyses of 28 samples showed an average deviation from the mean of only 1.5 p.p.m. or about 1.5 per cent error. The greatest deviation noted was in one sample containing large quantities of grease (155 p.p.m.), where a variation of + 7 p.p.m. or 4.5 per cent was found for one analysis. The number of analyses showing deviations from the average noted were as follows:

P.p.m. Deviation	Number of Analyses	Per Cent
0–1	41	48.8
2–3	31	36.9
4–5	10	11.9
6–7	2	2.4

It will be seen that 85.7 per cent of the individual analyses fell within ± 3 p.p.m. of their mean and 97.6 per cent within ± 5 p.p.m.

The grease content of the settleable solids was determined by the difference between grease and suspended solids analyses made on raw sewage and the sewage after settling. Calculation of the percentage grease in the settled solids compared with the average grease content of the fresh solids collected at corresponding plants, as determined by the procedure described in the first paper of this series (2), showed good agreement, especially since the sewages and sludges were all catch samples. A comparison of the averages shows only 0.3 per cent difference between the two sets of determinations.

The comparisons between precipitation and evaporation methods produced variations in both directions. This is probably due to variations in the kind of greases found in different sewages. Some contain grease which hydrolyses on evaporation, others not. Still others may contain soluble non-lipoidal matter which is retained and extracted by the evaporation method but passes through the filter when the precipitation method is used.

The effect of acidification before and after evaporation is indicated by the following figures:

	Acid Added Before Evaporation	Acid Added After Evaporation	Ppt. Method
Highland Park	58	66	66
Morristown	123	142	133
Bound Brook	115	135	131
New Brunswick	41	38	45

It is evident that most of the samples showed hydrolysis of fat as indicated by the lower result obtained with the pre-acidified evaporation method. Another explanation is the possible re-formation of fatty acid salts after the acid is evaporated off. The fourth sample gave substantially the same results whether pre or post acidified and evidently contained no hydrolysable grease.

Outline of the Alum Precipitation Method

1. Pour a four-liter sample of the sewage into a beaker of five-liter capacity.
2. Add with constant stirring a quantity of alum solution containing 25 mgm. of Al for each liter of sewage.
3. Allow floc to settle.
4. Filter through a Buchner funnel prepared with a layer of muslin cloth, a circle of Whatman No. 1 filter paper covered with about a gram of filter aid applied in slurry form.
5. Wash beaker with a few ml. of distilled water and pour on filter; wipe beaker with ether-saturated filter paper.
6. When filter is dry, remove mat and wipe sides of funnel with the same piece of filter paper used to wipe the beaker to remove adhering residue.
7. Place mat from which cloth has been removed together with the paper with which adhering residue was removed from beaker, in a small porcelain dish.
8. Add 10 ml of 10 per cent HCl to dish and dry at 60° C.
9. Transfer residue to an extraction thimble and extract in a soxhlet apparatus for twelve hours with petrolic ether into a weighed flask.
10. Distill off excess ether and dry at 60° C. over night.
11. Cool in a desiccator and weigh immediately.
12. Calculate results as follows:

$$\frac{\text{Weight of flask and grease} - \text{weight of flask}}{4} \times 1000 = \text{p.p.m. grease.}$$

Conclusions

1. A method for determining grease was developed which gives consistent results.

2. This procedure is an improvement over the standard method because no evaporation is required and a large sample can be taken for analysis without inconvenience.

3. The average variation between analyses by this method of the same sample is less than 2 per cent.

4. The grease extracted contained no nitrogen and an average of only 2 p.p.m. ash.

5. The grease content of settleable solids as determined by this method applied to sewage before and after settling appears to check the grease found in the fresh solids collected at the plants at which sewage sample was taken.

6. The precision of this method makes it possible to study grease in relation to sewage treatment more thoroughly than was allowable with previous methods.

An article by Okun, Hurwitz and Mohlman * on the subject of new methods for determination of grease in sewage was recently published. One of the methods employed by them was similar to that described in this paper. As both laboratories were working on the problem simultaneously and the methods vary somewhat the text of this paper does not include reference to prior published work.

References

1. Standard Methods for the Analysis of Water and Sewage.
2. *This Journal* 13, 467 (May, 1941).
3. Pomeroy, R., and Wakeman, C. M. *Manuscript.*

* Okun, D., Hurwitz, E., and Mohlman, F. W., *This Journal*, 13, 485 (1941).

THE EFFECT OF DRYING TIME ON THE DETERMINATION OF SOLIDS IN SEWAGE AND SEWAGE SLUDGES

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In connection with the revision of the Eighth edition of *Standard Methods for the Examination of Water and Sewage,* the question has been raised, by members of the committee on revision, as to the length of time that total and suspended solids should be oven dried. To shed some light on this question, the Bird Island Laboratory undertook a series of tests to ascertain the minimum drying time necessary to insure dryness and to determine the effect of prolonged drying on the weight of the residue. This note presents the results of these investigations.

The first set of tests was made as a control to make certain that changes in weight (if any) during drying were not due to variations in the weight of the crucible itself. Ten Gooch crucibles (average weight 15.58695 gms.) were burned in a muffle for 30 minutes at 600 deg. C., cooled in a desiccator and weighed. The crucibles were then subjected to heating in an oven at 103 deg. C. for three periods of 30 min. each with cooling and weighing at these intervals. The average change in weight was as follows:

	Avg. Change in Weight
After 30 min.	−0.00013 gm.
After 60 min.	−0.00014 gm.
After 90 min.	+0.00004 gm.

These variations seem well within the probable experimental accuracy of weighing and show, as was to be expected, that if crucibles are burned in a muffle at 600 deg. C. they will undergo no appreciable change in weight when placed in an oven at 103 deg. C.

The second set of tests was also made on a control to ascertain if changes in weight (if any) during drying were due to variations in the weight of the asbestos mat. Ten Gooch crucibles with asbestos mats were dried in an oven for 30 minutes at 103 deg. C., cooled in a desiccator and weighed (average weight 15.6735 grams; average weight of mat 360 mg.). These crucibles were then subjected to additional heating in an oven at 103 deg. C. for four periods of 30 minutes each, with cooling and weighing following each 30-minute heating period. The average change in weight was as follows:

Time of Drying	Avg. Weight of Mat	Change in Weight
After 30 min.	.03600 grams	
After 60 min.	.03608 grams	0.00008 grams
After 90 min.	.03606 grams	−0.00002 grams
After 120 min.	.03602 grams	−0.00004 grams
After 150 min.	.03603 grams	0.00001 grams

These variations are certainly within the limit of accuracy and show that after a crucible mat is prepared and dried in an oven at 103 deg. C. for 30 minutes it will attain constant weight. Thus changes (if any) in the weight of crucibles and residue during prolonged drying must be in the residue and not in the crucible or mat.

Having established this fact, the third series of tests was concerned with the effect of drying time on the residue. A number of tests were made on sewage samples from various parts of the Buffalo treatment works, as follows: raw sewage, grit free sewage, settling basin influent and settling basin effluent. Fifty ml. of each sample were filtered through weighed Gooch crucibles and then dried for 5 consecutive periods of 30 minutes each, with cooling in a desiccator and weighing at the end of each drying period.

The results of these tests were as follows:

Average Results in Parts per Million of Suspended Solids

Time	Raw Sewage 18 Samples	Grit Free Sewage 19 Samples	Clarifier Influent 20 Samples	Clarifier Effluent 23 Samples
30 min.	214	226	218	124
60 min.	210	223	216	122
90 min.	212	225	217	122
120 min.	208	221	213	120
150 min.	210	223	217	122

On the basis of these eighty tests, it appears that any changes after 30 minutes drying are almost within the limit of accuracy of the test. The differences of approximately 1 to 2 per cent are within the sampling errors of the test. Certainly for all practical purposes it is evident that one hour's drying time is sufficient.

One factor became evident in this particular study and laboratory technicians should give it some consideration. If the drying agent (calcium chloride) in the desiccator is not relatively fresh, crucibles placed within the desiccator will actually gain weight during cooling after drying, due to the picking up moisture from the calcium chloride until an equilibrium is reached with the vapor pressure of the moisture in the desiccant. A gain of as much as 5 per cent has been observed. Therefore, it appears that the drying agent should not be retained too long in the desiccator and a crucible with residue should be cooled in the same desiccator in which it was cooled before weighing and for the same length of time.

It was reasoned that if sixty minutes were sufficient for drying suspended solids in sewage, the same drying time would be sufficient for a determination of total solids if the sample were evaporated to complete dryness on a steam bath before being placed in the drying oven. This seems logical because the thickness of the film of residue in the evaporating dish is not as great as the thickness of the mat plus residue in the Gooch crucible.

In view of this hypothesis, it was decided that data obtained from a series of determinations of total solids in raw sludge, digested sludge and digestion tank supernatant liquor would apply to determinations of total solids in sewage where the thickness of the residue in the evaporating dish would certainly be much less than in the case of sludges. A series of tests was therefore run on raw and digested sludge and supernatant liquor. The weighed samples were evaporated on a steam bath to apparent dryness and were then dried in an oven at 103 deg. C. for 1 hour, 2½ hours, and 5 hours, with cooling in a desiccator and weighing at the end of these intervals of time. The following results were obtained:

Drying Time	Per Cent Dry Solids (Average)		
	Raw Sludge 30 Samples	Digested Sludge 24 Samples	Supernatant Liquor 20 Samples
1 hour	4.954%	8.049%	0.328%
2½ hours	4.940%	8.037%	0.329%
5 hours	4.924%	8.017%	0.327%

The volatile matter content of the raw sludge was approximately 73 per cent, that of the digested sludge approximately 49 per cent and that of the supernatant liquor 52 per cent. On the basis of the above data, it appears that 1 hour drying is sufficient for sludges and, therefore, by inference for the total solids determination on sewages.

Inasmuch as there is little or no change after 1 hour, any loss of volatile compounds on drying must take place in the first hour or else it is not an appreciable factor. On the other hand, experience in this laboratory as elsewhere [1, 2] has indicated that drying to constant weight may cause an appreciable loss of volatile compounds in samples of supernatant liquor from digestion tanks, and in chemically conditioned sludge cake.

In fact, any change in the weight of the residue caused by drying the solids more than 1 hour is a minor consideration compared to that caused by lack of uniformity in samples particularly those taken from such heterogeneous mixtures as raw sludge. This is shown by quadruplicate analyses made on the same samples of raw sludge.

In the analyses, gallon bottles of samples of raw sludge as received by the laboratory were thoroughly shaken and the portion for each analysis poured immediately into an evaporating dish. A thorough reshaking preceded each pouring. The following results indicate that the neck of the sample bottle acts as a dam which prevents a flow of uniform sludge.

In a second set of tests, gallon sample bottles were thoroughly shaken and a portion transferred immediately to an evaporating dish by use of a glass "theif."

Series A—Total Solids in Poured Samples

Sample	Average 4 Tests	Maximum	Minimum	Difference (Max.-Min.)
1	3.32%	3.59%	2.54%	1.05%
2	4.87%	5.40%	4.61%	0.79%
3	4.16%	4.40%	3.91%	0.49%
4	6.28%	6.36%	6.15%	0.21%
5	5.77%	7.39%	4.87%	2.52%

Series B—Total Solids in "Thiefed" Samples

Sample	Average 4 Tests	Maximum	Minimum	Difference (Max.-Min.)
1	5.29%	5.44%	5.07%	0.37%
2	4.90%	4.95%	4.79%	0.16%

Inasmuch as this particular study was concerned with the effects of drying time on sewage residues, further tests on sampling procedures were not made. However, it appears from these preliminary tests that further work on the technique of sampling (particularly raw sludges) is more important than additional studies on the effect of prolonged drying.

Based on the above delineated series of tests on the effect of drying time on sewage and sewage sludge residues, it is recommended that the standard procedure for determining suspended solids in sewage and total solids in sewage, digestion tank liquors, and sewage sludges should specify a period of drying of one (1) hour in an oven at not more than 103 deg. C.

References

1. A. M. Buswell and G. E. Symons, Part II, Solids Balance, Ill. State Water Survey *Bulletin* No. 29, p. 29 (1929).
2. *Standard Methods for the Examination of Water and Sewage*, 8th Ed., 1936.

THE CHATHAM SEWAGE TREATMENT PLANT AND ITS OPERATION *

By Charles Lose, III

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The first move for a sewerage system in Chatham came about 1912. At that time a plan for a partial system was submitted and when it was put to a vote by the people, it was defeated. From 1912 until 1938 the question was brought up at intervals, in each instance the plan calling for only a partial system. In 1938 the Village took advantage of a grant by the P.W.A. to share the expense of constructing a sewerage system which would take in the entire village. Plans were drawn up by Thomas F. Bowe of New York City and approved by the Village Board on July 30, 1938.

It was not until October 6th of the same year that work was actually started. In the meantime, final details were worked out and bids accepted for ten miles of sewers and the pumping station and treatment works.

Both contracts were completed by the last of November, 1939, at an approximate cost of $240,000. Due to the cold weather no house connections had been made. The operation of the plant was therefore postponed until the spring.

During the winter, stream survey work was started to determine how badly the Stein Kill was polluted and the source of this pollution came. Several sewage outlets from various sections of the village were found which emptied directly into the stream or were connected with the storm sewer which also empties into the stream.

Approximately four miles above the plant a paper mill is located which dumps untreated waste material into the stream. The waste consists for the most part of vegetable fibers and dyes. From the mill down to the Kinderhook Creek, into which the Stein Kill flows, the pollution decreases until it is barely noticeable.

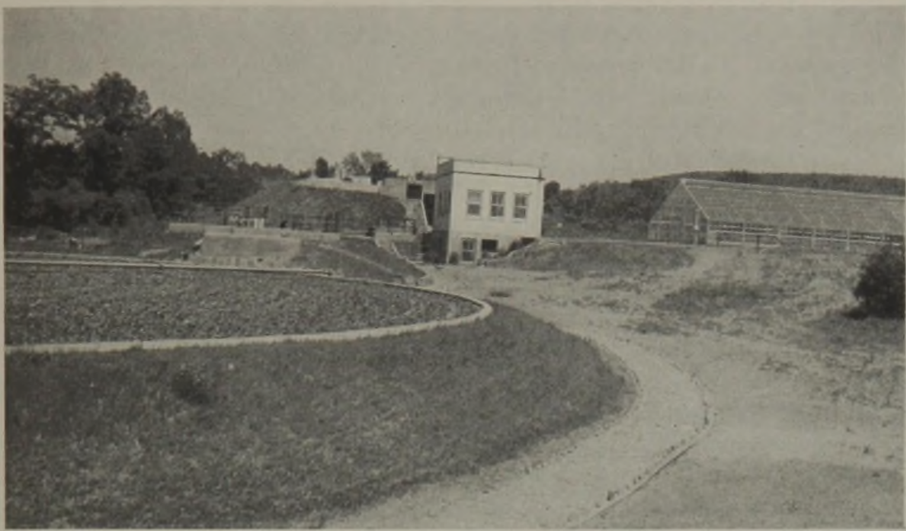
To correct this condition the Village has required all residents whose sewer connections either directly or indirectly empty into the stream to make connections with the sanitary sewer. Inasmuch as the paper mill is not within the village limits, nothing has been done in connection with disposal of its waste.

When spring came, it was found that surface water had seeped into the lines and had run down to within a hundred yards of the plant, where one of the trunk sewers made an overhead crossing of the stream. This water froze and burst several lengths of the exposed cast iron pipe. When the sewer line was intact again, permission to make house connections was obtained from the consulting engineer. On April 4, 1940, the plant started operation. Since that time house connections

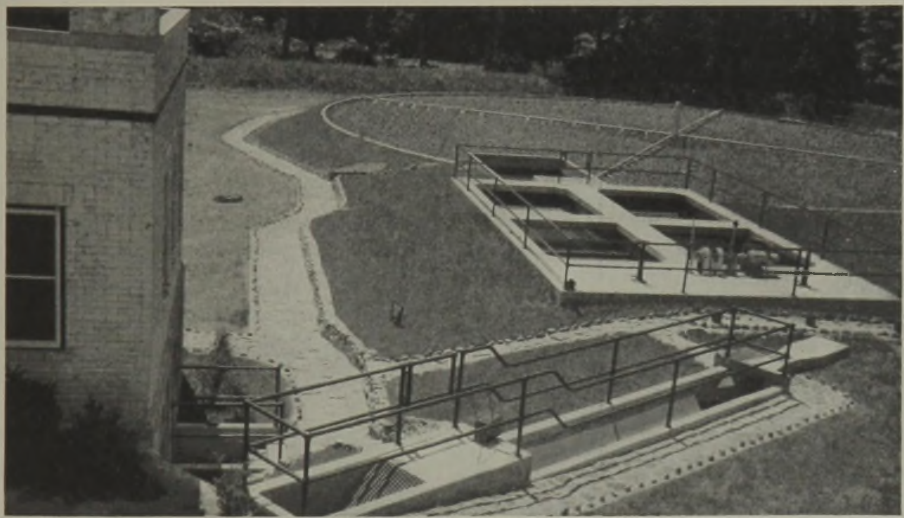
* Presented at the Fall Meeting of the Capitol District Section of the New York State Sewage Works Association, Chatham, Oct. 24, 1940.

have been made at the rate of six a week and at the present time approximately one-sixth of the village is using the sewerage system.

The treatment works is of the separate sludge digestion-trickling filter type designed for a maximum daily flow of 500,000 gallons from 4,000 people.



Chatham, N. Y., Sewage Treatment Plant, 1940. View from near final settling tank looking toward control house, and digestion tanks.



Chatham, N. Y., Sewage Treatment Plant, 1940. View from top of digestion tank looking toward final settling tank.

One hundred and fifty yards above the plant the two main sewer lines meet and the sewage flows from that point through a 15-in. line to the plant where it enters the grit chamber. The grit chamber, which is 28 ft. long, 3½ ft. wide with a 7-in. wide grit channel, is equipped with a hand-cleaned bar screen and four 8-in. baffle plates, behind which the grit collects as the sewage flows through the Venturi flume which is used for measuring the sewage flow.

At the end of the grit chamber, there is a 10 by 8 in. Y which feeds to the primary settling tanks. The two primary settling tanks are 35 ft. long, 10 ft. wide and 10 ft. deep. They are equipped with influent baffle boxes, scum trough and piping, effluent weirs, sludge and scum collectors and sludge removal piping. The sludge and scum collectors in each settling tank are of the straight line type consisting of flights attached to a double strand of chain.

A single-drive Jeffreys speed reducer has been provided for the two tanks. The capacity of each primary settling tank is 21,000 gallons and at the present rate of flow the detention period with one tank in use is about four hours.

The effluent of the primary settling tanks flows to the dosing chamber which is 17 ft. long and 10 ft. wide and provided with a Yeoman's simplex dosing siphon. With the present adjustment the sewage rises to an elevation of 13 in. and then flows to the filter distributor which is of the four-arm rotary type.

The trickling filter has a diameter of 110 ft. and is designed to treat sewage at a rate of approximately 400,000 gallons per acre foot per day. It has a manhole at both the influent and effluent ends of the main underdrainage channel.

The effluent chamber at the lower end of the filter is provided with a mud valve through which the sewage flows to the final settling tank and with a shear gate valve which can be used to bypass the final settling tank.

If necessary the flow from the dosing chamber can bypass both the filter and final settling tank and empty directly into the Stein Kill, the receiving stream.

The underdrainage system of the filter is of vitrified clay and consists of grilles and channels made in one piece. They cover the entire floor except for the main drainage channel which is covered with iron gratings. Over the tile and grating there is 6 ft. of crushed stone.

The final settling tank has the same dimensions as the primary tanks, the only difference being the scum collector which is absent from the lower tank. From the secondary settling tank the effluent flows through a 15-in. line to the stream.

From the sump of the primary and secondary settling tanks an 8 in. line runs to the sludge pump in the basement of the control building and from there to the digesters. There is also a valve connection at the grit chamber making it possible to pump the sludge into the grit chamber instead of to the digesters. It has seemed desirable at times to pump the sludge from the secondary settling tank into the incoming flow at the grit chamber when the solids content of the sludge dropped to only about 2 per cent.

The digestion system is a Dorr two unit type; the primary with a fixed steel cover, heating coils and stirring mechanism, the secondary with a floating cover. Both tanks, which are 20 ft. in diameter and 20 ft. deep, are equipped with gas collection equipment, pressure and vacuum relief valves and flame trap assemblies. The secondary is capable of storing 1250 cu. ft. of gas beneath the floating cover. From here the gas is piped to the basement of the control building.

There are four sludge draw-offs from the primary and two from the secondary tank. The supernatant liquor of the digesters can be returned to the grit chamber from the secondary. The sludge is piped to the drying bed through a 10 in. line from either digester.

The drying bed is 67 ft. long, 39 ft. wide, glass-enclosed. It has doors at both ends large enough for a small truck to enter. The underdrains are of 4-in. and 8-in. tile and are covered with a layer of gravel and a layer of sand. It has been divided into two compartments with a sludge valve for each.

The control building is a two-story brick structure. The ground floor is divided into a laboratory-office and a chlorine room which is equipped with a scale and two Everson chlorinators. These are so designed that it is possible to pre- and post-chlorinate with either machine. A small locker and toilet room are also located on the main floor. The basement includes the sludge pump, a coal furnace, a gas furnace, gas piping and meter, and two circulators which pump hot water to the digesters.

A sewage pumping station at the lower end of the town takes care of the sewage flow from approximately 400 people who could not be served by the main gravity system. It is equipped with two vertical centrifugel pumps, one pump being motor driven and the other driven by a combination gasoline engine and motor drive. When operated electrically the station is automatic. The wet well of the pumping station is equipped with manually cleaned bar screens.

The operation of all of the mechanical equipment has been generally satisfactory although there have naturally been some operating difficulties. The most important of these has been the clogging of the nozzles of the distributor. This clogging is partly caused by water-soaked matches which cannot be gather up with the grease and scum in the settling tank as they are below the surface. They eventually work their way down into the dosing siphon and from there to the distributor. The second cause of clogging in the distributor is from frogs. They get into the settling and dosing tanks and are siphoned down to the distributor nozzles. At one time as many as twenty dead frogs have been taken from the distributor.

The clogging of the sludge pump is another though not as important difficulty. When the sewer lines were finished all the construction debris was not removed from the lines. Most of it has been caught in the bar screen but pieces of wood from one inch to four inches square have reached the settling tank and have been pulled up as far as the pump when sludge is being drawn off.

The only other difficulty encountered is keeping the lower manhole of the trickling filter clean. The elevation of the weir in the final settling tank is higher than the floor of the tricking filter. Consequently a scum builds up in the manhole and the filter does not get the aeration it should because of the limited amount of space for air in the underdrain of the filter.

The operation data summarized from daily averages from May 1st to September 30th are as follows:

Flow	114,300	gal. per day
Screenings	1	cu. ft.
Sludge Added	62	cu. ft.
pH	7.1	
Chlorine	3	lbs.
Res. Cl.	0.5	p.p.m.
Suspended Solids		
Raw	188	p.p.m.
Tank	59	p.p.m.
Filter	19	p.p.m.
Final	11	p.p.m.
Overall Red.	94	per cent
D.O.		
Filter	7.3	p.p.m.
Final	7.3	p.p.m.
B.O.D.		
Raw	198	p.p.m.
Tank	83	p.p.m.
Filter	23	p.p.m.
Final	14	p.p.m.
Stream above	17	p.p.m.
Stream below	17	p.p.m.
Overall Reduction in B.O.D.	93	per cent

OPERATING RESULTS AND EXPERIENCES, SEWAGE TREATMENT PLANT, BIRMINGHAM, MICHIGAN *

By Stanley J. Mogelnicki

Superintendent

The Birmingham Sewage Treatment Plant consists of an office, laboratory, locker room, and filter room on one grade level; a garage, screen room, and sludge pump and boiler room on a grade level below; and a sewage pump room on a third level in the basement. Immediately adjacent to and back of the above building are housed the primary and secondary clarifiers, and back of this building are the aerators. All of these tanks are on the top grade level. Just north of the main building are the two digestion tanks situated in the side of a hill.

Design Data

The sewage treatment plant is the activated sludge type with separate sludge digestion. The design data are as follows: design flow, 1.5 m.g.d.; one primary clarifier of a capacity of 72,800 gal. and detention period of 1.17 hr.; 8 aeration tanks of a capacity of 68,000 gals. each and detention period of 6.5 hr. for a flow of 1.5 m.g.d., plus 25 per cent of this flow for return sludge; two secondary clarifiers of a capacity of 72,800 gal. each, and a capacity of 900 gal. per sq. ft. of surface area per day based on 1.5 m.g.d., plus 25 per cent of this flow for return sludge; two sludge digestion tanks of total capacity of 48,000 cu. ft. or 3.2 cu. ft. per capita based on 15,000 population. The actual capacity is 4.08 cu. ft. per capita based on connected population of 11,800.

Although the plant was designed for an average flow of 1.5 m.g.d. to serve a population of 15,000, the plant now has an average flow of 1.5 m.g.d. with a connected population of only 11,800. This flow is due to the fact that the sewerage system is of the combined type, and the flow varies from a minimum of 0.8 m.g.d. in dry weather, to a maximum of 3.0 m.g.d. in wet weather. An overflow is provided ahead of the plant to bypass flows in excess of 3.0 m.g.d. directly to the river. The sewage is strictly domestic, since Birmingham is a residential city with no industries.

Operation

Screen.—Sewage is first passed through a Rex mechanically cleaned bar screen with 1 in. clear openings. The screen is cleaned by an electrically operated rake, which is automatically controlled by a time clock and float switch. The screen has worked very satisfactorily to date. For disposal of the screenings a triturator is provided to grind the screenings and return them to the sewage. The grinder has per-

* Presented at the Seventeenth Annual Meeting of the Michigan Sewage Works Association, Lansing, June 18, 1941.

formed its duty better than expected and no trouble with plugged pumps has resulted.

Sewage Pumps.—Three sewage pumps of the horizontal centrifugal type have been provided to lift the sewage to the primary clarifier. Two of the pumps are driven by electric motors and one is driven by a gas engine. No troubles have been encountered to date.

Primary Settling.—The plant was put into operation on August 24, 1939. Only primary treatment was employed for the first few weeks, but double sedimentation was necessary since no bypass line was provided from the primary tank and it was necessary to pass the sewage through the secondary settling tanks in order to get it out of the plant.

The primary settling tank is of the straight-line type and is equipped with Rex sludge collectors. This mechanism has not given any trouble. However, the sludge hopper in this tank has, on three occasions, become partly filled with grit, which is not removed due to lack of a grit chamber, and plugged the sludge withdrawal line, so that it was impossible to open the line and made it necessary to dewater the tank with a gasoline pump and clean out the grit. Approximately one-half of a cubic yard of grit was removed each time.

The settling efficiency of the tank is about 50 per cent for design flow and varies between 30 and 50 per cent for greater flows. The primary sludge withdrawn from the tank is about 97 per cent water due to waste activated sludge.

Aeration with Activated Sludge.—The aeration process was started about three weeks after the initial opening of the plant. The aeration tanks are 30 ft. square with a water depth of 10.5 ft. and are equipped with American Well Works, down-draft type, mechanical aerators. These machines have been operating without trouble and have produced a good effluent over a wide range of sewage strengths. The eight tanks are operated in series since it was found that an unequal distribution of flow resulted when the tanks were operated as two batteries in parallel.

The concentration of suspended solids in the aeration tanks is maintained about 1000 p.p.m. On occasions the solids concentration dropped to 700 p.p.m. for a week at a time and no difference in the quality of effluent was noticed, except if there were too great a fluctuation in the strength of the sewage.

Supernatant liquor from the digesters was returned directly to the aerators and no difference was noticed in the quality of the sludge or the effluent. Sludge overflowing from the digesters was also handled directly by the aerators and no difference in quality of the effluent was noticed, but the sludge turned gray in appearance and had a tendency to become slightly bulky.

The aerators have been operating on an average of 67.5 per cent of the time for the past year and have removed from a minimum of 50 p.p.m. of 5-day B.O.D. to a maximum of 467 p.p.m. The average removal is 98 p.p.m. The average power consumption is 0.336 kw.h. per pound of B.O.D. removed. The average sludge index has been 69. As a general rule, the higher solids concentration in the mixed liquor the better the quality of the effluent, but the difference is so small that it does not warrant carrying the solids above 1500 p.p.m.

It was noticed that the quality of the effluent was better when the sludge index was low and that the B.O.D. of the final effluent was almost twice as great when the sludge index increased. Changes have been noticed in the appearance of the activated sludge at various times with an accompanying change in sludge index. Whether these fluctuations are seasonal has not yet been determined.

In July, 1940, some trouble was encountered with the chironomid fly in the activated sludge. The larvae became so plentiful that poor settling was obtained in the secondary clarifiers. The tanks were dosed with pyrethrum powder and most of the worms were killed and the condition overcome.

Secondary Settling.—These tanks have a high efficiency for settling activated sludge. The suspended solids of the final effluent vary from 1 to 28 p.p.m. depending on flow, with an average of 8 p.p.m. The B.O.D. of the final effluent varies from 1 to 26 p.p.m. the average being 11 p.p.m.

Return activated sludge is withdrawn and pumped to the aerators with one of two constant speed pumps. The total amount returned is 360,000 gal. per day. The per cent of flow returned varies from 36, for a flow of 1 m.g.d., to 18 for a flow of 2 m.g.d., and 24 for a flow of 1.5 m.g.d. No difficulty has been experienced in maintaining a certain solids content in the mixed liquor, because no sludge blanket is carried in the final clarifiers. The sludge is continuously removed as quickly as possible, and in this way the solids concentration varies with the flow, and keeps the mixed liquor solids at the same concentration for varying flows.

Operation of Sludge Digestion Tanks.—One of the digestion tanks was filled with sewage in the first few days of operation, and about 500 gallons of sludge from the city's old Imhoff tank was added for seeding purposes. Primary sludge was added daily and the tank was heated. In three weeks gas was being produced at the rate of 2,000 cu. ft. per day and in five weeks at the rate of 10,000 cu. ft. per day. No trouble was experienced in starting this digester, so on November 17, 1939, the other digester was seeded and put into service. The two tanks were operated in parallel. These tanks performed satisfactorily until January 12, 1940, when a large excess of activated sludge was wasted. Two days after the addition of the activated sludge the digesters bulked. The overflow from the digesters, which had been truly supernatant liquor containing from 200 to 400 p.p.m. of suspended solids, was sludge of 3 per cent solids content. The bulking was more or less expected, but not hoped for. In an attempt to overcome the bulking, the contents of each tank were circulated by pumping the sludge from the bottom of the tank into the top. Circulating the sludge resulted in a remarkable settling effect on the sludge; however, it was two months before the bulking entirely ceased.

After the bulking, the digesters were put into series operation in an effort to get a good supernatant. Operating the digesters in series was a rather difficult procedure with fixed covered tanks because a gas storage tank was not provided, but two-stage digestion was successfully employed from January, 1940 to April, 1941, and a supernatant liquor was obtained that was not sludge. In April, 1941, the secondary digester was taken out of service in an effort to empty the tank to find the cause for shearing of the drive pin on the driving mechanism of the sludge stirring equipment. When the tank was half empty, however, the sludge withdrawal varied so much in solids concentration that it was not feasible to filter. In order to empty the tanks, the primary clarifier and one secondary clarifier were emptied and used to store the sludge from the digester until the trouble was remedied. When the sludge depth in the digester had been reduced to three feet, the sludge was so thick that the pumps could not remove any more. Backwashing and adding activated sludge had no bulking effect, as was hoped for. Finally a vacuum furnace cleaner was obtained and the tank was vented and then entered. It was necessary to get into the sludge with waders and agitate the sludge by means of water from a hydrant. A fire hose with a 4 ft. piece of 2-in. pipe as a nozzle was used. A submarine inspection by the Braille system did not reveal any breakdown of the mechanism. After three hours of agitation with water the mechanism was started and it continued to operate. Evidently the sludge was too thick for the scrapers to plow through. The sludge was only 10.3 per cent solids, but it was so thick that it had the appearance of a jelly-like mass. The only reason that can be given for the sludge to take on such a characteristic is that the sludge was not freshly digested but stale digested sludge which had not been withdrawn.

The tanks are at present being operated in parallel in hopes that the same trouble will not again be encountered. The sludge stored in the clarifiers was pumped back into the digesters.

Results obtained have proved that operating the sludge stirring and scum breaking mechanism continuously gave a more uniform rate of gas production than when operating the mechanism intermittently. Also continuous operation of the mechanism kept the scum thickness at a maximum of 6 inches; and as has been proven above, the sludge solids were more concentrated.

The gas production to date has averaged 8,000 cu. ft. per day or about 0.68 cu. ft. per capita per day. The reduction of volatile solids by digestion has been 70 per cent.

Gas Utilization.—Sludge gas is produced and collected in two Hardinge digestion tanks of the fixed-cover type. The gas domes of these tanks are connected to a 3 in. gas main in which the gas is piped to the building where it is metered and then distributed to a gas engine, hot water heater, gas-fired boiler and the laboratory.

There are no facilities for purifying or storing gas. It is used directly as it comes from the digesters, and no trouble has resulted from the use of the unscrubbed gas. However, the lack of a storage tank sometimes results in a shortage of gas, usually during sludge pumping periods or during withdrawal of sludge from a digester. The total daily gas production is sufficient to operate the above mentioned equipment, but a shortage occurs due to fluctuations in the rate of gas production. These fluctuations range from a maximum rate of 16 cu. ft. per min. to a minimum of 2 c.f.m. and the result is an insufficiency of gas at times. However, to alleviate this condition, sludge pumping periods have been established at six-hour intervals in order to maintain the rate of gas production as nearly uniform as possible. This procedure has helped the situation, but a gas holder is still very desirable.

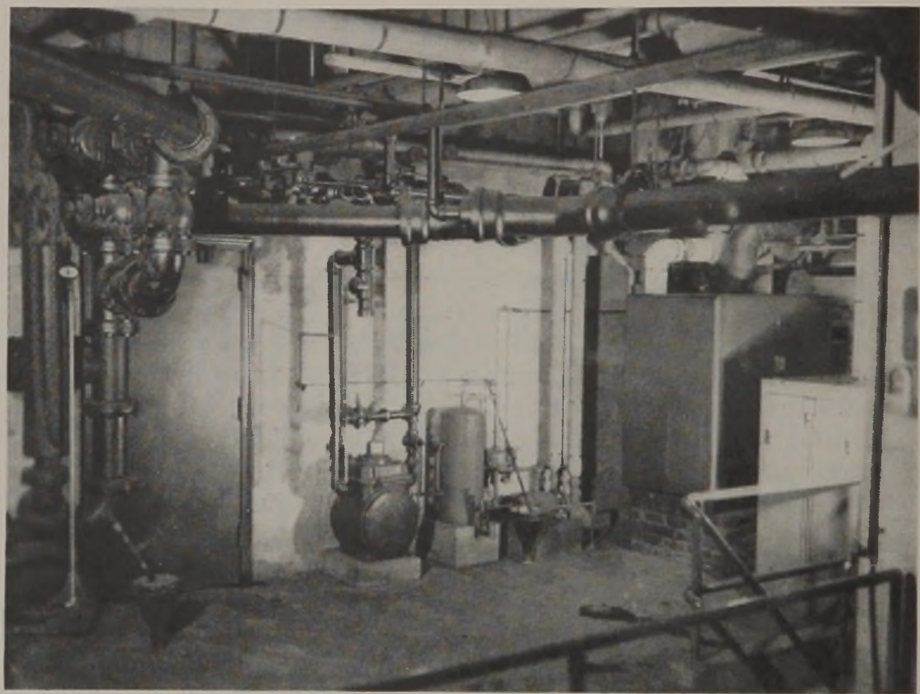
To remove the moisture from the gas lines, automatic float-operated condensation traps were provided. These proved to be unsatisfactory due to plugging of the small opening in the traps. Also gas was allowed to escape. Since the latter was very dangerous, the automatic traps were replaced with manually operated traps which are drained every day. Some trouble was encountered last winter with a carry-over of moisture into the waste-gas burner line, which became plugged with frosted crystals of moisture. This condition might have had a harmful end had it not been discovered when pressure in excess of 10 in. was noticed on the gas pressure indicator, which is a U-tube filled with colored water and connected to a gas outlet in the laboratory. The pressure relief valve is set to release gas when the pressure exceeds 10 in. of water. It is now planned to install pressure relief valves on the gas dome of each digestion tank to relieve excess pressure which might build up in case the gas line should become plugged between the existing pressure relief valve and the digestion tanks.

The gas is used principally as fuel for the gas engine, but can be used to fire a gas boiler, which can be used to heat either the building or the digestion tanks or both. Primarily, the gas is used to operate the gas engine continuously, because of greater economy. The engine is directly connected to a sewage pump which lifts the raw sewage to the primary settling tank.

The engine is equipped with a governor operated by a float in the wet well which directly increases or decreases the speed of the engine in accordance with the flow of sewage into the plant. The governor is adjusted during dry weather periods so that the float will vary the speed of the engine to conform to the sewage flow, which varies from a minimum rate of 0.5 m.g.d. to a maximum rate of 1.5 m.g.d. During wet weather periods when the sewage flow reaches a maximum rate of 3.0 m.g.d., the governor is ''opened up'' to permit the float to vary the speed of the engine from a minimum speed which would pump at a rate of 1.5 m.g.d. to a maximum speed at a rate of 3.0 m.g.d. Continuous operation of the engine results not only in a saving of power, but also in a smooth flow through the plant, which would not be possible with the other pumps.

The gas engine is a four-cylinder Climax engine with overhead valves. It develops 32.5 horsepower at a rated speed of 1000 r.p.m., and has a maximum speed of 1200 r.p.m. It is equipped with the following: storage battery, starter, generator, crank, thermostatic safety switch, oil pressure safety switch, top oiler, magneto, force feed oil filter, Ensign gas regulator and carburetor, water cooled exhaust manifold, and an exhaust waste heat boiler.

The engine has no radiator, but water is circulated through the engine, around the exhaust manifold, and through the waste heat boiler and then through the coils in the digestion tanks where the water gives up its heat to the tank contents. The temperature of the cooling water varies with the speed of the engine from 120° to 140° F. The waste heat boiler on the exhaust line increases the temperature of the water



Gas boiler and appurtenances, Birmingham, Mich.

from 4° to 5° F. above the temperature of the water as it comes from the engine. If the cooling water should reach a temperature of 180° F., due to faulty circulation, the thermostatic safety switch would stop the engine. The quantity of water circulated through the heating coils in the digesters is not metered, but the heat recovered from the engine is enough to keep the two digesters (180,000 gal. each) at a temperature between 85° and 90° F.

The oil system in the engine is a force-feed type. The oil is pumped from the crankcase by a positive type pump through an oil filter, then directly to the bearings and other wearing parts of the engine. No oil can reach the bearings, etc., unless it comes from the oil filter. In case no oil should reach the bearings, the oil pressure safety switch would stop the engine.

The engine was "broken in" according to the manufacturer's recommendations. During the "breaking in" period the crank-case oil that was drained showed no indications of breaking down. Because of this fact, after the engine was "broken in," the oil was changed only four times a year. The only reason for the oil to withstand so many hours of operation is that the oil filter kept the oil clean. The oil filter was inspected, and cleaned if necessary, at least once and sometimes twice a week. The oil filter element was found to have a coating of ¼ in. or more of sludge. We have always used R.P.M. Delo oil in our engine. This is a special compounded oil with a naphthenic base, which, it is claimed, dissolves gums and holds them in the form of an emulsion. To date we have had no trouble from using this oil, the cost of which is no more than that of other oils.

Another oiling system on the engine is the Marvel Inverse Oiler, which lubricates the valves and upper parts of the cylinders. The oiler automatically proportions the amount of oil fed into the engine, so that at slow speeds a small amount of oil is fed, but at high speeds a large amount is fed. The oil is introduced into the intake manifold and is drawn into the combustion chamber with the gas from the carburetor. The oiler is operated by the vacuum in the manifold.

Marvel oil was used in our engine for the first year of operation and no trouble was encountered from sticky valves. The consumption of this oil was 15 gallons for the first year. Since the cost of Marvel oil is about three and one-half times that of the other oils, a substitute for Marvel oil was tried. However in a few weeks the valves began to stick and the performance of the engine became so poor that it was necessary to replace some of the valves. With new valves, the engine operated satisfactorily, but sticky valves became a frequent occurrence. After a few more weeks of operations, the valves became so worn that it was necessary to again replace them. We began using Marvel oil again and no trouble was encountered. Our experience proved it was much more economical to use Marvel oil than to replace valves and have the engine out of service. The engine was furnished with an Edison-Splitdorf magneto. After a few weeks of operation it was found that the winding in the magneto could not withstand the damp conditions in the pump room, so it was necessary to replace the magneto with a moisture proof American Bosch magneto which has given excellent performance. It was noticed that better engine performance was obtained with the American Bosch magneto, because of a "hotter" spark, which seems to necessary when sludge is used as a fuel. Also Champion and AC spark plugs were found to give better performance and last longer than other types of plugs. Only recently trouble was encountered in the magneto, but could not be located. The magneto was found to produce an intermittent spark, but when it was tested all parts showed no defects. However a new condenser solved the problem which had mechanics baffled.

Sludge gas is brought to the engine in a 2 in. wrought iron pipe under a pressure of 10 in. of water. The flow of gas to the engine is regulated by an Ensign gas regulator which operates under a pressure of 7 to 10 in. of water. The regulator is connected to the carburetor in such a manner that a constant mixture of gas and air is maintained at all speeds. This results in a minimum consumption of gas. After initial adjustment, these two pieces of equipment have required no attention and have given excellent performance.

A noteworthly feature about our gas-engine installation is an exhaust line which consists of 70 ft. of 2½ in. wrought iron pipe. There is a possibility of excessive back pressure, however, the size of the line seems ample to prevent such a possibility. No determination has been made for back pressure other than operating the engine with and without the exhaust long exhaust line, and no difference in performance was noted. An interesting fact is that no condensation trap was provided on the exhaust line. However, only a few days of operation proved the necessity of one. The trap is drained daily and the amount of water obtained varies from a cupful to two gallons, depending on the humidity of the air.

The yearly average of sewage pumped by the engine is about 1.0 m.g.d. To pump this amount of sewage with the engine means an average saving of about 175 kw.h. or about $2.00 per day. The total cost of maintenance and repair to April 1, 1941, has been about $200, so the net saving for the past 18 months amounts to $895 or about $1.65 per day.

Based on our records, the saving made with the gas engine amounts to three times the saving that would be made if the gas were used in the boiler to heat the digestion tanks and the building.

Sludge Filtration.—The plant is provided with an Eimco rotary vacuum filter with an area of 62.5 square feet. Ferric chloride and hydrated lime are used to condition the sludge. The filter is operated on continuous mix. Sludge is pumped to a mixing tank by a small diaphragm pump and conditioned and then filtered.

Much actual experimentation was performed with the filter in an effort to get optimum results, from the standpoint of yield and cake moisture. Buchner funnel tests were used but actual trials on the filter with varying amounts of chemicals, water, and sludge were more practical, since the method of mixing, detention period, and elapsed time following the mix until the sludge was on the filter cloth were the controlling factors, besides the proportion of chemicals.

For our sludge, it was found that best results were obtained by having only 2 to 3 inches of submergence of the drum in the sludge. In this way a longer time of drying was allowed. In order to keep the process a continuous one, the speed of the drum was increased so as to filter the sludge as fast as it was fed to the filter when the feed was set at a minimum. The increased speed of the drum produced a dryer cake, but water was expelled on the blow. To relieve this condition, the spacer in the filter head between pick-up and "drying" vacuums was removed and also another improvement was made on the filter head to allow vacuum on the drum for the maximum amount of time.

These changes enabled us to operate the drum at a speed of 0.8 r.p.m. and get a filter cake that averaged 75 per cent moisture and obtain a maximum yield of 17 lb. of dry sludge solids (excluding chemicals) per square foot per hour.

The average amounts of chemicals used and average yield obtained since the changes are: lime, as available CaO, 9.8 per cent; ferric chloride 2.2 per cent; yield 10 lb. dry sludge solids per square foot per hour.

Filter cloth life has not been very long, the average length of life being 200 hours. It has also been found necessary to wash the filter cloth with dilute acid at least two or three times a week.

The kind of cloth used is cotton and it is wound with a phosphorous-bronze wire. When the supply of wire furnished by the manufacturer was used, a galvanized iron wire was tried on one winding. However this iron wire rusts very easily and the rust spreads on the cloth. This wire has not been very satisfactory.

Sludge Disposal and Utilization.—The filtered sludge is dumped in stock piles on another part of the 66-acre tract on which the plant is situated. After being exposed to freezing and thawing during the winter the sludge become fluffy and powdery in the spring upon drying. Although there has been much demand for this sludge, none of it has yet been sold. A study is being made in an effort to commercialize on the sludge.

The sludge was used this spring for top dressing the lawn. It must be said that the sludge really did wonders for the grass. The grass in one week became a rich green in color and has grown so fast it has kept us busy to keep it mowed.. The grass became much thicker and made the lawn spongy and resilient.

Last fall liquid sludge was pumped on one part of the lawn.

A small diaphragm pump and 250 ft. of fire hose were used to pump the sludge from the digester to the lawn. The sludge was of 8 per cent solids concentration and formed a black layer on top of the grass about 2 inches deep. A plank was used to float the material around on the lawn and get it uniform. This layer of sludge completely disappeared by this spring and left a grass that is growing luxuriantly. The liquid sludge definitely was shown to be a good vitalizer; however the sludge cake applied this spring on other parts of the lawn has given results equally as good as those obtained by the liquid sludge applied last November. In our case the liquid sludge has not shown any results more remarkable than those of the sludge cake.

Maintenance and Personnel

No report on operation of a sewage plant would be complete without some reference to the general maintenance of the plant and grounds. The total personnel includes a superintendent, an assistant, two night shift men and a relief man. The plant is under 24-hour supervision and is kept clean and neat at all times and the plant grounds are kept up so as to present a pleasing appearance.

Operating Cost

The 24-hour supervision of the plant makes the operating cost rather high, however it was decided that with the equipment involved, it was warranted. The 24-hour attendance, however, enables hourly composite samples to be taken. The total operating cost as of June 1, 1941 has been $20,688.56 or $22.79 per million gallons of sewage treated.

Plant Improvements

The gas-fired boiler that was mounted on a brick foundation, with an oil-burner set under it so that oil could be used for heating when gas was not available, proved to be unsatisfactory due to continual clogging of the flues. A small oil-fired boiler was installed last January, so that now there are two separate units.

A piping connection was made so that supernatant could be returned directly to the aerators.

Other contemplated improvements or additions are a grit chamber, a gas-storage tank, and a motor-operated elevator to replace the hand-operated dumb waiter that is used to transport chemicals to the filter room. Also a ventilating system has been designed and will be installed.

THE OPERATOR'S CORNER

Conducted by W. H. WISELY, Executive Secretary*
Federation of Sewage Works Associations
Box 18 · · Urbana, Illinois

THE OPERATOR SHALL HAVE HIS DAY . . .

three of them, as a matter of fact, when the Federation opens its Second Annual Convention at the Hotel Pennsylvania in New York on October 9–11, 1941. And why shouldn't the Operator have a Day, when everyone else does, from the First Lady of this fair land to the lowliest canine?

A glance at the program for the meeting, a copy of which has already reached your desk, will reveal that plant operation is truly the theme of the meeting. No less than fourteen (count 'em) items in the program pertain to various phases of plant operation. The Operators' Breakfast on Saturday, October 10, is intended to afford you an opportunity to bring your own problems to the attention of men of broad experience for an exchange of ideas.

Have you ever seen such an array of prominent men in our profession as has been gathered by Program Chairman Gilcreas and his Committee to present this program? Papers covering timely operation topics by Gould, Coburn, Fair and McKee, Martin, Scott, Olewiler and Genter; the Operation Symposium lead by Larson of Illinois and including such speakers as Hyde, Tatlock, Griffin, Donaldson, Berry and Lanphear; the Operators' Turn-Table, conducted by Van Kleeck of Connecticut and Poole of Indiana; everyone of them an acknowledged expert in our field! The program speaks for itself. It should be obvious that it is adequate justification for your attendance.

Other features? The complete exhibit of equipment and supplies required in sewage works, the unusual entertainment for your pleasure and enjoyment, the inspection trip of the interesting treatment plants serving New York City, the chance to see old friends and make new ones—all topped off with the thousand and one attractions that only New York has to offer!

Mrs. Karl Mann and her Ladies Entertainment Committee have worked hard and long to arrange an interesting and pleasurable interlude for the ladies. Why not combine business and pleasure by taking in the Convention as a part of that well-earned vacation? It will be one that will not be readily forgotten!

Where and when does the Operator have His Day?

IT'S NEW YORK IN OCTOBER!

* *Also Engineer-Manager, Urbana and Champaign Sanitary District.*

EXPERIENCES IN ODOR CONTROL

The Corner continues in its endeavor to assemble practical operation experience pertaining to problems of general incidence. Anyone finding this article of interest should duly appreciate the contributions of the following plant operators, who have co-operated in its preparation:

P. L. Abernathy, City Chemist, Hickory, North Carolina
W. A. Allen, Superintendent, Pasadena, California
Arthur Cary, Supt. Public Works, Fairport, New York
Chas. H. Copley, Superintendent, New Haven, Connecticut
A. E. Fiscus, Chief Operator, Terminal Island Plant, Los Angeles, California
Harold Gnaegy, Superintendent, Highland, Illinois
L. R. Jennings, Superintendent, Owosso, Michigan
F. Wayland Jones, Supt. South Plant, Stockton, California
W. M. Kunsch, Superintendent, Danbury, Connecticut
Bard Livingstone, Superintendent, San Bernardino, California
Irving Manahan, Asst. Supt., Briarcliff Manor, New York
W. S. Mahlie, Chemist of Water and Sewage, Fort Worth, Texas
George Martin, Superintendent, Green Bay, Wisconsin
Phil J. Martin, Acting City Manager, Tucson, Arizona
H. A. Miller, Superintendent, Hobbs, New Mexico
R. G. Miller, Superintendent, Vinton, Iowa
Chester F. Proudman, Superintendent, New Canaan, Connecticut
Homer V. Read, Superintendent, Olney, Illinois
T. D. Reedy, Superintendent, Flint, Michigan
W. H. Roach, Superintendent, Carrington, North Dakota
L. T. Roberton, Engineer, London, Ontario, Canada
W. A. Sperry, Superintendent, Aurora, Illinois
T. M. Wardwell, City Manager, Rhinelander, Wisconsin

General

All sewage, due to its organic character, is a potential source of odor. The path between "potential" and "potent" is a short and easy one—hence one of the most vexing of all problems of the sewage works operator.

That many odor complaints pertaining to sewage works are largely of psychological origin is undoubtedly a fact, although we who spend much time about such plants are perhaps too ready to accept this alibi. It is one of the peculiarities of hydrogen sulfide gas (the most common of the objectionable, odorous compounds formed in sewage) that it "paralyzes" the sense of smell so that one who is exposed to it for a short time may not continue to observe the characteristic "bad egg" odor. Thus, there may be some truth in the common assertion by the complainant that "you are around this stuff so much that you do not notice it," when he calls upon the plant operator for relief.

The operator of a plant located critically with respect to residential property functions under an appreciable handicap. It is reasonable to expect complaints from a neighboring resident who must gaze at the plant each time he attempts to enjoy his front porch—particularly if he was an objector to the plant location, or to the bond issue which financed the project. Many times, a sewage works is constructed to avoid legal liability for stream pollution and, when the works are built, the same municipality finds itself legally liable for creating a nuisance because a critically located site was chosen. These legal aspects as well as costs of some odor control measures often would have justified a greater initial expenditure for a better site and longer outfall sewer. Where the plant has been located critically, the operator must satisfy legitimate complaints by employing known odor control devices and those of psychological origin by good housekeeping, attractive landscaping and the development of good will.

Occasionally, the sewage works is accused of odors which actually emanate from other sources, such as garbage and rubbish dumps, rendering plants and some industrial plants. At Stockton, California, the South Plant was blamed for odors produced at Japanese truck farms and a commercial fertilizer plant, which sources were proven to complainants by Superintendent F. Wayland Jones by means of the wind direction indicator described in the GADGET DEPARTMENT, this issue.

With respect to the prevalence of this problem, we must probably admit that some odor exists in every sewage treatment plant but that the degree to which odors are confined to the plant site varies widely due to local conditions. In some plants, no odor abatement measures other than good general operation practice are necessary, yet in others, particularly those located in warmer climates, odor control is almost equally as important as the production of a satisfactory effluent.

THEORETICAL CONSIDERATIONS

Before presenting the odor control measures practiced in various plants, it appears proper to briefly discuss the character and contributing causes of sewage odors.

Odors arising from the formation of hydrogen sulfide in the sewage are usually more important from a control standpoint than are those originating at the sewage treatment units and produced incidentally to the operation of the units or to the disposition of screenings, grit, scum and sludge. The hydrogen sulfide odors are discernible by the sense of smell in concentrations as low as one thousandth part per million and may be carried a distance of several miles over low, flat terrain in the evening of a hot, humid day. The incidental odors may be more offensive since they evolve from the putrid organic acids of decomposition, decaying grease, etc., however, their travel range is not nearly so wide.

Hydrogen sulfide formation is accomplished by certain sulfate-reducing bacteria which act upon the sulfur compounds contained in the public water supply, industrial wastes and excreta. These bacteria are most active at temperatures above 70° F. and rapidly increase in number during flow to the plant and through primary treatment units. Their numbers decrease during aerobic secondary treatment. Another group of sulfur bacteria which oxidizes hydrogen sulfide thrives in the secondary treatment units, hence the absence of odor in a stable plant effluent.

Gases produced by the bacterial action upon sulfates, during the time of flow in sewers and primary tanks, remain entrained in the sewage until opportunity is afforded for release into the atmosphere by splashing or spraying as at overflow weirs and trickling filter distribution systems. Consequently, odor difficulties are much more common in trickling filter plants than in the activated sludge type, especially where the filters are preceded by Imhoff tanks in which stale, non-flowing portions "seed" the influent sewage. Shorter primary tank detentions and the rapid oxidation of sulfides in aeration units serve to reduce odors in activated sludge works.

Summarizing, the important factors encouraging hydrogen sulfide formation are:

1. A high sulfur or sulfate concentration in the raw sewage.
2. Prevailing sewage temperatures of 70° F. or above.
3. Overlong detention time in the outfall sewer and primary treatment units, affording opportunity for sulfate-reducing bacteria to function.
4. Sources of "seeding" of sulfate-reducing bacteria such as stale sludge deposits in sewers, channels and tanks, or supernatant liquor from sludge digestion units.

Recognition of these factors will aid the operator in analyzing an odor problem and developing proper methods of control. Removal or preliminary treatment of certain industrial wastes may reduce the sulfate concentration or temperature; more frequent screen cleaning may reduce impounding of sewage in the outfall, thus lessening the time of flow and preventing deposition of stale solids; preliminary treatment or disposition of a strong supernatant liquor by other means than return to the raw sewage may reduce inoculation or seeding of sulfate-reducing bacteria and the consequent acceleration of hydrogen sulfide production. Complete control of any one of the first three factors listed above may result in a satisfactory solution of the entire problem.

Hydrogen sulfide is also toxic in effect, being definitely hazardous when present in concentrations (in air) above 50 p.p.m., although prolonged exposure to even lower concentrations should be avoided. The gas is also corrosive in action upon metal, concrete and paint and has caused extensive damage to concrete sewers in warm-climate states.

Maintenance of the H_2S concentration in sewage below 1 p.p.m. is considered adequate to control odors and corrosive effects.

Control of Hydrogen Sulfide

Methods of reducing hydrogen sulfide formation have been classified into (*a*) physical methods of controlling sewage flow to and through plant units and of removing fumes already present, (*b*) methods involving modification of the sewage character by dilution with stream water or plant effluent and (*c*) methods involving chemical treatment.

Physical Methods of Control.—At Olney, Illinois, combined sewers on flat grades cause low dry-weather velocities resulting in sufficient time of flow to produce a stale, septic sewage at the plant. Superintendent Read minimizes this effect by frequent cleaning of the bar screen to maintain unrestricted flow in the outfall. Further reduction in time of flow to secondary treatment units is accomplished by the use of only one of the two primary sedimentation tanks, the single unit being adequate to remove suspended matter during the hot, dry summer months.

Correction of primary tank short-circuiting by improved inlet baffles permitted the summer use of only two of the four tanks at Aurora, Illinois, thus effecting a marked reduction in detention time and opportunity for hydrogen sulfide formation. Greater frequency of primary sludge pumping is also practiced in summer to reduce septic sludge accumulations which harbor sulfate-reducing bacteria.

The lower end of the outfall sewer to the treatment works is utilized as wet-well storage capacity at Green Bay, Wisconsin, and Owosso, Michigan. Superintendent Jennings at Owosso relates the following experience:

> During the winter months when low temperatures prevail and the screen room windows are closed, we made it a rule to keep the sewage level high enough in the inlet sewer to seal off gases from the screen room. This was all right in winter but as warm weather came I noticed a change in the odor to that of stale sewage, even outdoors at the settling tanks. I then tried lower pump float settings so that sewage would not be backed up into the plant inlet sewer and could detect definite improvement in the odor and appearance of the raw sewage in a short time.

Contrary to most experience, odors in the plant at Green Bay, Wisconsin, increase in winter, when deep freezing of the ground reduces infiltration to sewers. Hydrogen sulfide formation, caused by the longer detention in the sewer and clarifiers, is controlled by keeping the influent sewer pumped clean. Over the week-end, when flows are normally lower than during the week days, a by-pass station at the upper end of the intercepter is partially opened, admitting about 1 m.g.d. of river water, which flushes septic sludge accumulations to the plant and has materially reduced odor production.

Removal of H_2S already present in the raw sewage by means of pre-aeration tanks is not a complete odor control measure unless provision is made for the disposition of the gases removed. An unusual arrangement at Flint, Michigan, is described by Superintendent T. H. Reedy, who reports that fumes from the enclosed pre-aeration unit, located between the Imhoff tanks and filters, are drawn out by exhaust fans and discharged to the trickling filter underdrains. Absorption of the gases in the filter has been found very successful. Chemist W. S. Mahlie of Fort Worth, Texas, has made laboratory studies of the effectiveness of pre-aeration with chlorinated air. The idea appears well founded but the results were disappointing since little improvement in odor abatement was observed until the chlorine demand of the sewage was satisfied. The chlorine demand of the sewage is rather high, due to the presence of strong packinghouse wastes, consequently the method was not considered economically feasible. Conditions at Fort Worth are such that all of the factors favoring H_2S formation are present and control of odors is a paramount problem, as yet not completely solved (see *This Journal,* **11**, 1, 68 and **11**, 3, 472).

Collection and disposition of malodorous gases given off at weirs and other minor points at which turbulence or splashing takes place has not been attempted at many plants. An unusual experience, now apparently aimed toward a successful conclusion, is related by Chief Operator A. E. Fiscus of the Terminal Island Plant at Los Angeles, California:

We have had some little experience at our Terminal Island Sewage Treatment Plant in attempts at odor control. Certain of these experiences might be entitled "what not to do" rather than otherwise.

Briefly described, the Terminal Island plant consists of a circular Dorr siphon-feed type clarifier, 85 ft. in diameter, a Dorr type digester, 75 ft. in diameter, bar screens, Parshall flume, incinerator, pumping and gas equipment, etc.

The plant treats the sewage from the San Pedro-Wilmington-Terminal Island area, having a population amounting to about 75,000, and the flow is nearly 4 m.g.d. While the sewage is principally domestic, two large fish canneries contribute considerably to oil, grease and solids, and are responsible for much of the odor at the plant, which at times is quite objectionable if not controlled. Suspended solids run from 300 to 700 p.p.m. and oils and grease to 220 p.p.m. As the plant is located adjacent to the large Fleet Base Airport of the Navy, considerable effort has been made to repress these odors.

Chlorine equipment, having a capacity of 250 pounds per day, was installed some years ago. The chlorinated water is passed through a wood stave tank, 2 ft. in diameter, and 8 ft. in height, the resulting solution seeming to give more efficiency than the chlorine. The solution is introduced both at the bar screen and again in the clarifier diffuser.

However, at times this has proved inadequate so it was decided to place redwood plank covers over the bar screen chamber where a balanced door was provided in order to rake the bars, over the clarifier launder into which the effluent spills after passing through the submerged ports and over the weir, and also over the Parshall flume chamber. All of these structures are in the open.

To remove the foul air and gas from the comparatively tight chambers thus formed, a brick chimney about 2 ft. square and 8 ft. high was built on the ground beside each structure and topped by a steel pipe 6 in. in diameter and 16 ft. high. In each chimney near the base a gas burner supplied with digester gas was installed and just above it a section of clay grid material as used in a domestic gas grate. The vent from the chamber was introduced into the chimney below the gas burner and the rising air passing through the heated iridescent section was raised to approximately 1200° F. and deodorized. It was intended that the rising hot air in the stack would cause a slight vacuum in the chamber, causing sufficient quantities of fresh air to be drawn through the cracks in the covers to replace and dilute the gas and bad air.

Going into operation, to all intents and purposes it worked splendidly. Odors, at least on normal days were practically eliminated and the chlorine feed greatly reduced.

Visitors were impressed and general satisfaction resulted until one day a number of months later, an operator had occasion to raise several covers over the clarifier launder and discovered that definite disintegration was commencing along the walls and especially at the water line. Apparently the space between planks in the covers, in place of furnishing sufficient air to dilute and carry out the hydrogen sulfide coming from the effluent due to turbulence caused by the spill, was furnishing about the right amount of oxygen to permit the formation of an acid condition with resulting attack on the concrete.

While, without doubt, proper sized air inlets, together with higher stacks furnishing more draft and greater displacement of air would have resulted satisfactorily, arrangements are now being made to remove a definite amount of air per minute by means of exhaust fans in each chamber, the foul air and gas to be carried to the incinerator in which digester gas is constantly being burned. Entering the incinerator, the air will pass through a fire brick grill maintained at a high temperature and exit to the atmosphere by way of the combustion chamber and stack.

It will be noted that the physical odor control measures mentioned here are all dependent upon features designed into the plant. Flexibility in primary tank capacity to meet wide variations in flow; provision for flushing the plant influent sewer; attention to details of wet wells, channels and inlet structures to discourage deposition of solids; exhaust fans for gathering fumes and discharging them to a suitable point of disposition; all of these are examples of design features which facilitate odor control.

Control By Dilution.—One of the earliest applications of dilution of the raw sewage en route to the treatment works was at Aurora, Illinois, where this was begun as an odor control measure by Superintendent W. A. Sperry in 1931. A valved connection to the intercepting sewer several miles above the plant is used to admit 1 to 2 m.g.d. of fresh river water to the sewer in hot, dry weather, thus accomplishing constant flushing of the intercepter and freshening of the sewage. The effectiveness of the method is proven by the increase in dissolved oxygen in the raw sewage and decrease in H_2S from about 3 p.p.m. to well under the critical value of 1 p.p.m. The method is considered practical and economical at Aurora even though the excess flow must be pumped to the trickling filters.

City Chemist P. C. Abernathy of Hickory, North Carolina, is also a strong advocate of the dilution procedure. He reports as follows:

The City of Hickory's disposal plant is of the chemical precipitation, separate sludge digestion type, with trickling filter and secondary clarifier. Our average daily flow is 450,000 gallons, consisting of 17 per cent hosiery mill dye house waste and 83 per cent domestic sewage.

Our plant is located about three miles from the center of the city but near a high class residential subdivision, so odor control is very important.

The plant was placed in operation in July, 1939. Very soon thereafter we began to have complaints of the odors from the families near the plant. We then began to apply chlorine to the raw sewage and were fairly successful in eliminating odors, however, the chlorine dosage was high and the cost was approximately $150 per month.

We then decided to try adding creek water to the raw sewage. A convenient point about 2.5 miles above the plant was chosen where the sewer line crossed the creek on piers. A small dam was built across the creek at a point where the creek water could be diverted by gravity through a 12-in. pipe into a manhole and a valve was placed in the line so that the flow of creek water could be controlled.

We then began applying creek water at the rate of approximately 450,000 gallons per day. This cut the detention time through the plant in half and instead of the raw sewage arriving at the plant in a septic condition, the raw had an oxygen content averaging 2 p.p.m. The B.O.D. of the raw sewage was changed from an average of 325 p.p.m. to 200 p.p.m., and the final B.O.D. from 28 p.p.m. to 15 p.p.m Plant odors were almost eliminated. However, we found that we had to apply chlorine at times during peak flows of dye house waste but the average dosage was cut from 25 p.p.m. to 2 p.p.m. This resulted in a saving of approximately $1,500 annually. Since the application of creek water we have not received a complaint about the plant odors.

The only reason we do not apply more creek water is that we are taking the full flow of the creek. We feel certain that if we could add approximately 100,000 gallons more dilution water per day, we could entirely eliminate dosing with chlorine because during rainy periods when we have infiltration added to the flow of the creek, we do not use chlorine.

It is our opinion that many plants can use dilution with creek water with beneficial results. Even if a plant is loaded to full capacity during peak day loads, the creek water could be added during low sewage flow, thereby building up a higher oxygen content through the plant, reducing the final B.O.D. and eliminating most of the odors.

It is not always convenient or practicable to add dilution water above the treatment works and many trickling filter plants, of which those at Highland, Illinois, and Hobbs, New Mexico, are typical, are able to attain most of the odor abatement advantages of dilution by continuously operating the final sedimentation tank sludge pump, when discharge is to the raw sewage. Although the actual percentage of effluent returned as a diluent of the raw sewage is not usually high, considerable benefit has been derived from the practice in smaller plants. Superintendent H. A. Miller of Hobbs, New Mexico, reports excellent results with recirculation of effluent as the only odor control measure employed. Various other effluent recirculation flow-sheets have been patented as proprietary processes and these list odor reduction among their advantages.

It may be interesting to note the effects of dilution upon the principal factors involved in H_2S production. A dilution water low in sulfates will reduce the concentration of sulfates in the raw sewage; river water is usually colder than sewage, thus the temperature of the diluted mixture is lower; by increasing the volume of flow, the sewer velocities are increased and sedimentation tank detention periods are decreased, shortening the time in which H_2S producing bacteria can function; the increased flow tends to flush septic sludge deposits from sewers and channels and to further reduce the numbers of sulfate-reducing bacteria by the added dissolved oxygen and general freshening effect.

Where it may not be possible to use stream water for dilution, clean condensing or cooling waters from industries or spent air-conditioning water may be utilized in some cases. For most effective results, the dilution water should be low in sulfates and temperature and control of the volume should be possible.

Control by Chemical Treatment.—Chlorine, which reacts directly with hydrogen sulfide to precipitate free sulfur and also destroys the bacteria which produce H_2S, is by far the most widely used odor control panacea at this time.

At Highland, Illinois, where the plant is located in a park and golf course, dilution by effluent recirculation (about 25 per cent of the flow being returned) is supplemented by chlorination. A dosage of about 10 p.p.m. is applied to the raw sewage at the screen chamber, affording a residual in the primary tank effluent ranging from a minimum of 0.75 p.p.m. to a maximum of 2.0 p.p.m. at 6:30 A.M. The residual is not carried for odor control alone, Superintendent Gnaegy reporting that a stable primary sludge, improved digestion tank operation and effective filter fly control are additional advantages derived from the practice. (A casual observer might conclude that Highland gets its money's worth!)

The Flint, Michigan, plant is located adjacent to the County Infirmary and Superintendent T. H. Reedy varies the time of chlorination to meet each day's requirements. A dosage of 4 to 5 p.p.m. is applied to the trickling filter influent after pre-aeration, from 8 to 24 hours daily.

Procedures at London, Ontario, and Olney, Illinois, are typical of those employing simultaneous "split feed" of chlorine at more than one point of application. L. T. Roberton at London reports that chlorination for control of activated sludge aeration tank odors was begun in 1936, resulting in effective abatement of odors and generally improved plant operation. The dosage is small compared to the chlorine demand, averaging 3.91 p.p.m. for the 155-day chlorination season (May to October) of 1940, with a maximum of 5.02 p.p.m. in July. Approximately one-third of the total dosage is applied to the raw sewage at the plant inlet and the remainder at the activated sludge reaeration tanks. Superintendent Read at Olney has found simultaneous split-feed at the primary tank influent and filter influent to be better than single application at either point. The chlorination season here is also May to October and the dosage is varied between 2 and 5 p.p.m. depending upon the septicity of the sewage and wind direction. In prolonged dry weather periods, dosages in excess of 5 p.p.m. are required. Several residences are located within a distance of 500 ft. to leeward of the Olney plant.

The procedure of W. M. Kunsch at Danbury, Connecticut (Fig. 1), is an excellent example of the flexibility of chlorination in meeting local requirements. From 1937 to 1940, the rather common practice of chlorinating the settled sewage during the season of May 15 to September 15 was followed. During the current 1941 season, however, modifications are being tried to control the more intense odors which accompany flooding of the filters. Superintendent Kunsch advises:

> Chlorine is applied at a manhole on the line 500 ft. ahead of the trickling filter "flow equalizing" manhole, this distance allowing from 4 to 8 minutes mixing time. Samples are taken for residual tests at the equalizing manhole, at which point we have tried to keep the residual chlorine at about 0.3 p.p.m. To do this has required an average dosage of about 5.5 p.p.m. (220 pounds per day), the peak reaching 9 to 10 p.p.m.

at noon and minimum dropping to 2.5 to 3 p.p.m. at midnight. The residual obtained with this dosage would seldom carry through to the final settling tanks. Therefore the amount of disinfection obtained was probably not great. However, any odor that may have been present was effectively controlled. No complaints have ever been received that were traceable to the trickling filters. In fact the lack of odor was so surprising that this year I have been experimenting with a different method of dosing.

Our psychoda fly control is quite a problem and we have been forced to flood our filters about every eight days from mid-April on. For about three weeks after May 15 no chlorine at all was applied. No unusual or carrying odors were noticed until we flooded our filters during a warm spell. Then, suddenly, we had plenty of odor, which is natural since the water drained from a flooded filter can hardly be said to have had any treatment except settling. (Flooded filters stand approximately 12 hours.) In recent weeks we have applied chlorine on the days of flooding in somewhat heavier amount than when chlorinating daily. The day following flooding we drop the dose so that the 0.3 p.p.m. residual is obtained at the equalizing manhole. The third day we stop chlorinating entirely. To date this has apparently been accomplishing good results.

FIG. 1.—Sewage treatment works at Danbury, Connecticut, W. M. Kunsch, Superintendent.

The only ill effect of this method of chlorinating might be the retardation of bacterial action in the filter bed due to the higher chlorine residual (about 2 p.p.m.) on the day of flooding. From our own relative stability tests we cannot notice any such effect. Unfortunately we do not have the laboratory or equipment in which to make the more detailed examinations that would show the effect, if any. Our only substantiation therefore will come with the next test of 6-hour plant samples. If we find no harmful effects, the change in chlorine application will result in a considerable saving to us.

At San Bernardino, California, odor control is a major problem because the plant location is such that prevailing winds carry odors to a state highway 700 ft. distant and to a residential area beyond. Superintendent Bard Livingstone reports that control measures are aimed "to delay or prevent the formation of odors in the sewage before it reaches the plant and to confine the odors originating in the plant by collecting the Imhoff tank gases and deodorizing them by incineration."

Until recently, chlorine was applied at a point in the outfall sewer about 1.25 miles above the plant, the average dosage of 5.3 p.p.m. being sufficient to keep the H_2S concentration at the plant inlet at 1 p.p.m. or less. The chlorinator settlings were changed at 7 A.M. and 7 P.M. each day. Chlorine is also applied at the dosing tanks of the trickling filters, in sufficient quantity (4.0 p.p.m.) to hold the H_2S concentration below a maximum of 1.5 p.p.m. The application of additional chlorine to further reduce hydrogen sulfide is not considered justified because the slight odor remaining at the filters is dissipated before reaching the state highway or residences.

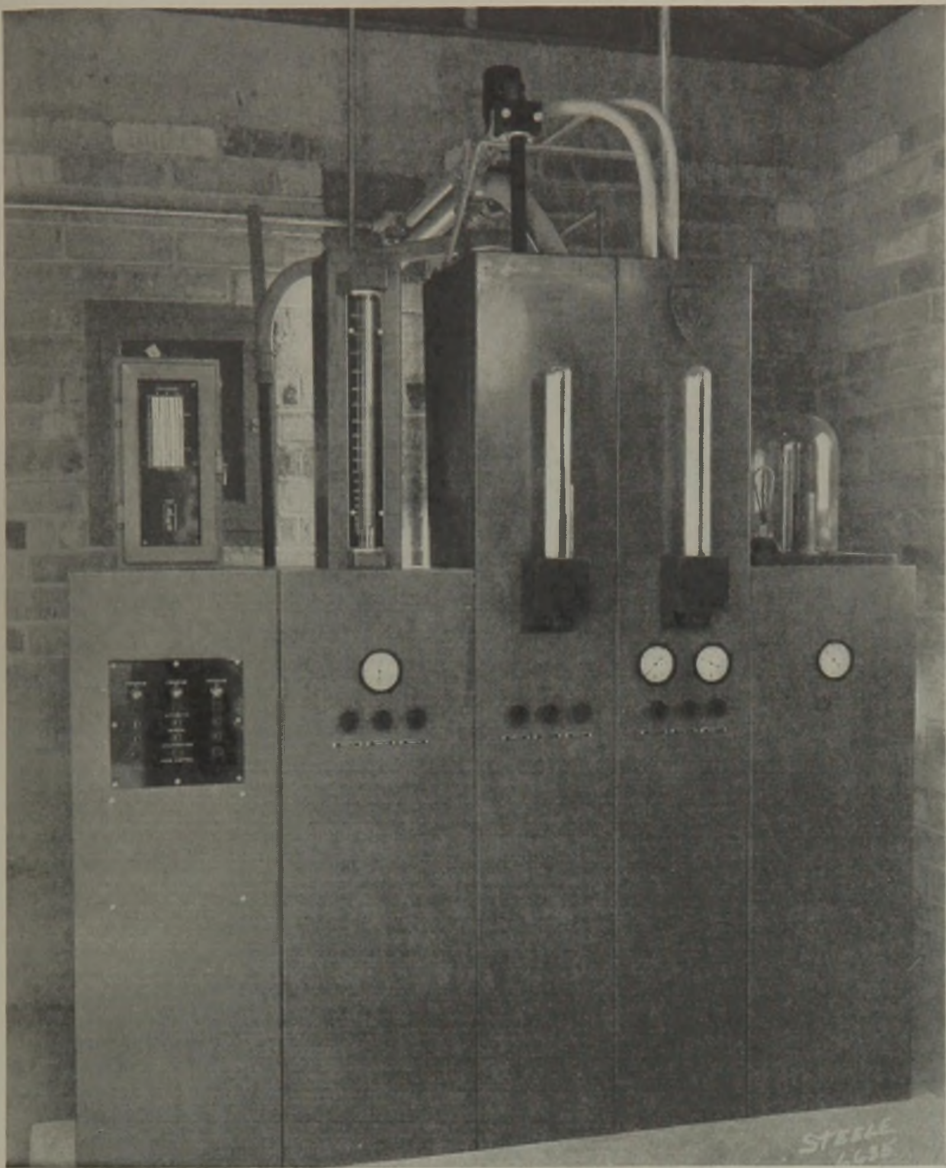


FIG. 2.—Machine affording optional chlorination on Scott-Darcey treatment at San Bernardino, California.

To reduce the chlorine cost (amounting to 28 per cent of the total plant operation cost during the above procedure), an automatic machine which manufactures ferrous chloride (Scott-Darcey Process) or which can be used for conventional chlorination, has been installed at the outfall sewer point of application. Ferrous chloride reacts chemically with hydrogen sulfide to produce ferrous sulfide, a stable compound which may slightly increase turbidity but has no other detrimental effect. The machine employed is entirely automatic and is equipped with an electric clock which makes it possible to operate on three different programs at any time during the day. The machine is shown in Fig. 2, the functions of the respective panels (left to right) being (*a*) electrical control, (*b*) solution water control, (*c*) iron solution control, (*d*) chlorine dosage control and (*e*) chlorine supply and feed.

The Scott-Darcey Process is also employed at Newport Beach, California, for hydrogen sulfide control; however, other odors contributed by fish canneries are not abated (see *This Journal,* **8**, 4, 599).

Acting City Manager Phil J. Martin, Jr. (formerly Water Department Superintendent), at Tucson, Arizona, has made detailed studies of treatment by the Scott-Darcey Process as compared to dosage with ferrous sulfate to control hydrogen sulfide odors and corrosion of a concrete outfall sewer. Early results indicate the Scott-Darcey (ferrous chloride) method to be slightly more economical; however, final conclusions based on the Tucson experience are not yet available.

Ability to absorb odorous gases has made activated carbon, a pulverized, heat-processed form of charcoal, a useful tool in controlling sewage works odors. Since it removes gases already formed, it is nearly always applied as a water slurry at the treatment works inlet in dosages of 3 to 5 p.p.m. At Fairport, New York, where intermittent hydrogen sulfide odors are experienced, the application of activated carbon to the raw sewage at critical times has yielded highly satisfactory results according to Superintendent Arthur Cary.

Several years ago, experiments in the use of ozone in the control of hydrogen sulfide were undertaken at San Bernardino, California. Unfortunately, hydrogen sulfide concentrations in the sewage at the time of the studies were too low to represent normal conditions and a series of mechanical difficulties interrupted the tests to such an extent that the results were not considered conclusive.

Odors Incidental to Plant Operation

Control of odors resulting from the various "fractions" of sewage, such as screenings, grit, scum and sludge, as these materials are progessively removed, is primarily a function of sound operation procedures and good housekeeping (Figs. 3 and 4). Cleanliness is imperative; it is frequently the mark of distinction between the well operated and poorly operated plant.

Prompt and sanitary disposition of screenings is emphasized by Superintendents Chester Proudman and Homer Read of New Canaan, Connecticut, and Olney, Illinois, respectively. At New Canaan, the screenings are taken immediately after removal to the burial pits which are 4 ft. wide, 10 ft. long and 4 ft. deep and each deposit is covered with 6 in. of earth. Where a large quantity of screenings is accumulated before disposal, a covered container is used for storage since an open pile of screenings produces odors and attracts flies.

If used as open fill, grit must be reasonably free of organic matter or odor will result, as at Rhinelander, Wisconsin, where the practice caused a minor problem early this year. Coverage of deposits of unwashed grit with a thin layer of earth is good insurance against odor.

Frequent skimming of primary tanks and liberal use of flushing water for hosing down walls, decks and channels is specifically recommended by nearly all of the operators represented here. Chloride of lime is employed as a deodorant at New Haven, Connecticut, at points which are difficult to maintain continuously clean. Any accumulation

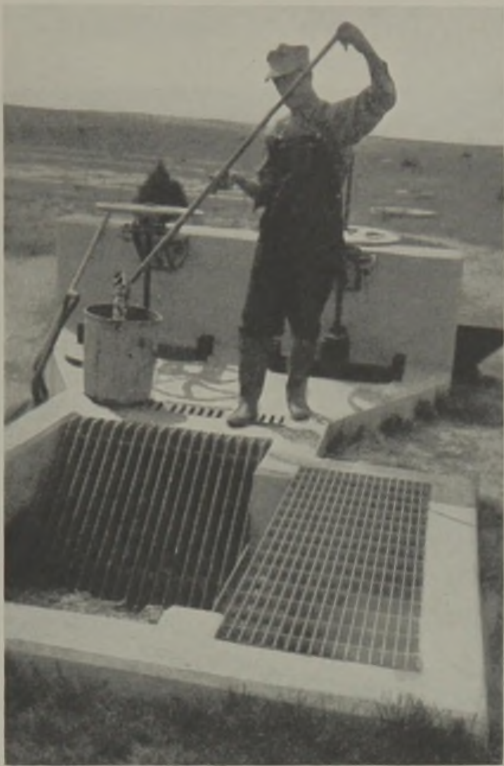


FIG. 3.—Sanitary and odorless method of handling screenings at Clinton, Illinois.

of grease is a potential source of foul odors and should receive prompt attention.

Activated carbon is reported to have been beneficial in reducing odors at Imhoff tank gas vents and open digestion tanks when applied as a slurry to the vents or merely dusted over the scum and hosed in. At Fairport, New York, Superintendent Arthur Cary reports favorably on his experience with activated carbon for deodorizing undigested final sedimentation tank sludge and incompletely digested primary sludge during drying on open beds:

> We have just finished removing the sludge from the final tank in very hot weather without a trace of odor, having added 105 pounds of activated carbon to the tank and allowing it to rest 24 hours before withdrawal of sludge.

Our digester is now heated, but from 1934 to 1940 carbon was used each summer by application to the sludge as drawn to the drying beds. This was done by hand and mixing took place as the sludge moved along the open channel to the beds. From 50 to 100 pounds per bed was used, depending upon the need for odor control. Each spring of the years mentioned, 500 pounds of carbon in solution was added directly to the sludge in the digester and mixed by pumping.

Odor problems have been encountered occasionally in connection with stack gases from sludge drying and incineration plants. At Pasadena, California, attainment of the high temperatures (1200 to 1400 degrees F.) necessary for complete deodorization of stack gases was

FIG. 4.—Grit receptacle mounted on push-cart affords cleanliness and minimizes odors at Danville, Illinois.

prohibitive in cost until a deodorizing plant of interesting and unusual design was installed in 1935. Superintendent W. A. Allen refers to a detailed description of the stack gas incineration plant as published in *This Journal,* **8**, 4, 593.

The landscaping plan may also be of value in sewage works odors control. Trees and tall shrubs, located between sources of odor and critical areas, are effective in lifting odors and diffusing them into the atmosphere, thus reducing the concentration. The effectiveness of shrubbery for screening plant structures and for attracting public attention from less desirable features of the plant, is pointed out by Proudman of New Canaan, Connecticut:

We have found it a very good policy from the point of view of psychological effect on visitors and citizens to keep our grounds in the best possble condition. Our lawns are cut regularly and we have seeded all around our sludge beds and sand filters. Flowering shrubs surround our primary tank and the entrance to our building, and evergreens are effectively placed to lend a cool, pleasant appearance to the landscape.

DIGESTER SCUM CONTROL AT BUFFALO, NEW YORK

By C. R. Velzy

Superintendent, Buffalo Sewer Authority

This contribution was received too late to be included in the compilation of experience in digester scum control which appeared in the July issue and is published here as a supplement to that article.

During the first year of operation at Buffalo the scum in the sludge tanks was not troublesome. In the spring of the second year, however, it was found that the scum layers were at times eight to ten feet deep and that the mass was relatively rigid and analyzed above thirty per cent in solids. The floating covers on the tanks became more or less fixed on the scum mass and had a tendency to crowd to one side exerting excessive pressures on the guide rollers. It became necessary to devise means to overcome the difficulty.

As work was started on this problem in the early summer months, the sludge tanks became more active and it was found that the scum softened of its own accord and became more fluid. The solids content dropped from above thirty to about fifteen per cent. Under these conditions the scum was fluid and gave no more trouble for the time being. It was anticipated, however, that winter conditions would again be accompanied by lower gas production, lower temperatures on the top material, and a dense scum layer of excessive depth. A procedure for overcoming the difficulty was, therefore, established.

The general principle upon which the procedure was based was that the scum, or top sludge, must not be permitted to stand long enough to become too dense and dry. In other words, it must be kept moving. In the moving process a portion of the material could be drawn off on a routine basis and disposed of by burning, thus reducing the volume of the scum.

A brief description of the piping arrangement will aid in understanding the operation. There are three supernatant pipes leading to three different elevations at the center of the tank, under the gas dome. Thus by raising or lowering the liquid level in the tank, the upper supernatant pipe can be brought to the surface of the liquid or a short distance below the surface.

By making simple additions to piping connections, it became possible to draw from the supernatant pipes with the sludge pumps. Other piping additions permitted pumping supernatant into the top of the gas dome.

It was obvious that scum having a solids content of thirty per cent could not be pumped as a liquid. The first effort, therefore, was directed to finding a means of handling this heavy material. A spray was designed and installed in the top of the gas dome, arranged so that water or supernatant liquor could be introduced in such a way as to wet down the entire area of the gas dome. The cover was then placed in such a position, vertically, that the upper supernatant pipe would lie about two feet below the top of the scum layer. When the scum had been sufficiently wet, it was found that it would flow into this pipe and the pipe connections were then adjusted so that the material thus flushed into the pipe could be pumped to the incinerator or into another tank. This procedure was successful. Permanent piping and connections were, therefore, made so that the procedure could be used without difficulty in the regular operating schedules.

It will be noted that there are two definite features in this procedure. One is a practical and easy method for wetting down the scum at the top of the tank in the area of the gas dome; the other feature is the provision for actually pumping material off of the top of the tank. Experience thus far has demonstrated that both these features are workable and it is anticipated that a routine procedure will be established which will keep the scum or the top sludge under control.

BARK FROM THE DAILY LOG

September 1—"Drafted" to advise in the design of additional sewage treatment facilities for a large U. S. Army Air Corps Technical School located near our community. The Quartermaster's office is faced with the problem of preparing plans and specifications and constructing a plant to serve 16,000 men—to be in operation in 75 days! Set up outline of design capacities and sketched layouts today.

September 3—Began installation of four new panels to our switchboard to mount deadfront disconnect switches. The board is obsolete by comparison with those in new plants and required opening of the master switch to work on any individual motor or control panel. This improvement adds safety, convenience and permits any single panel to be "killed" without interruption in service to equipment controlled by the others.

September 5—A mild furore accompanied our chemist's report that about 20 small but thoroughly dead fish were noted in Saline Fork a mile below the plant outlet, in the course of the routine weekly inspection. A careful check disclosed that the rendering works, located about a quarter mile downstream from us, was discharging a waste having a 5-day B.O.D. of 2600 p.p.m. With an outlet watercourse furnishing an amount of dilution less than our sewage flow for 50 per cent of the time, frequent stream inspection and sampling is imperative. We are thus constantly equipped with factual data to protect our municipality in case of unjustified complaint.

September 8—Made permanent repairs on the exposed 18-inch sewer at the creek crossing where youthful vandals had practiced "bombing" several weeks ago. The entire exposed section was encased in concrete with a minimum cover of 4 inches. Now let the "Luftwaffe" return!

September 9—Took down portions of the dosing tank piping and replaced several ells with plugged tees and crosses to facilitate flushing of the piping in the future. We can now perform this task much more conveniently and efficiently.

September 11—Returning home from "The Field" (Air Corps Technical School), a genuine thrill at having been able to help repaid us amply for our small participation in the rush job of extending the sewerage facilities there. Today we checked details of the completed plans which had been begun only 10 days ago! Just 65 days left to get the new plant in operation. (They did)!

When it **must** be done, our Army can do it!

September 13—Friday the thirteenth notwithstanding, the weekly stream inspection brought no bad luck. On the contrary, we were happy to be able to report in our notes that several hundred fingerling bullhead and perch were observed at the Two-Mile Station.

September 14—While on a week-end trip to Ohio, enjoyed a brief visit with Superintendent M. W. Tatlock at Dayton, who we found engrossed in his new sludge drying and incineration units. For some reason, like the well known bus-man, it appears impossible to take any kind of a trip without including an inspection of a sewage plant.

September 20—Persistence pays! Received notice that the National Youth Administration project (previously rejected) had been approved and that labor would be made available within the next month.

September 21—Began painting the concrete wall-coping at the trickling filters. The present coping is a replacement made six years ago after the original one had disintegrated badly in only nine years of service. Since the replacement, the coping has been treated with one coat of a coal tar base paint every two years and preservation has been excellent. Thorough cleaning and wire brushing precedes the paint application.

September 24—Cleaned 600 feet of a small branch intercepting sewer today after noting sluggish flow in the line. The "yield" was several buckets of brick bats and a large chunk of lead.

How they got there? Quien sabe?

September 25—At the last Board meeting, purchase of two suits of coverall uniforms with cap to match for each regular shift operator, was authorized to initiate the plan into future practice. The coveralls are practical, neat in appearance and ideal for use in any except hot weather, and replacements will be obtained by each man as necessary. For summer wear, the boys chose a neat but inexpensive shirt-trouser combination in light green.

September 28—Completed painting of the walls, piping and equipment in the pump dry well and can't realize it is the same place! The chronic dampness at this point has been eliminated by the new, sloped-to-drain floor installed in July, making it possible to do a good paint job and have it hold up.

October 3–5—In Chicago attending the First Annual Convention of the Federation of Sewage Works Associations—and what a meeting! The splendid technical program, the exhibits, the entertainment, the inspection tour, the chance to meet old friends and make new ones—all combined to make it memorable. Which reminds us that—

IT'S NEW YORK IN OCTOBER!

October 7—Painting sludge dump cars with coal tar base paint, practice being to do this annually. Each time cleaning of a series of beds is completed, the cars are hosed and swept clean to minimize corrosion.

October 8—Completed arrangements with a local farm manager for him to furnish trucks to haul away the sludge accumulation in our lagoon. A low bid of 50 cents per cubic yard had been previously received for moving this sludge to the stock pile. Now we have free labor (N. Y. A.) to load the trucks and free trucking service to take the sludge completely off the property!

October 14—Initiated the National Youth Administration project today, with five boys cleaning up woven-wire fences in preparation for painting. Will be allocated three more boys in the next few days.

October 16—Our lagoon is a horse-shoe shaped excavation which was originally intended as a temporary substitute for a final sedimentation tank, until funds became available to construct the latter unit. After 1929, when the final tank was built, the lagoon was used as an effluent "polishing" unit until 1938, when final tank sludge was discharged directly to the lagoon to relieve the load on the digestion compartments of the Imhoff tanks.

We have now discontinued this method of final tank sludge disposal but must remove the existing deposit of almost 1000 cubic yards before the lagoon can be restored to service as a supplement to the final sedimentation tank. Removal of the deposit was begun today with N. Y. A. labor. The humus is quite stable and odorless and, although the nitrogen content is only 2.75 per cent, should make an excellent soil conditioner.

October 22—While attempting to close a large gate valve in order to repair the check valve on the discharge line of the 3.5 m.g.d. sewage pump, we broke the threaded bushing through which the stem rises. Similar experiences are not uncommon at valves which are infrequently used and suggest that such valves should be occasionally operated so that they will seat without being forced when their use is required.

October 25—These N. Y. A. boys are turning out to be fairly good workers. Today, at the lagoon, one of them was so intent in getting his share in the truck that he hung up his sludge fork in the baggiest part of a co-worker's pants, inflicting several deep scratches in the anatomical region beneath. First we made peace. Then we gave first-aid by treating the wounds with iodine. Finally, after catching the casualty and repacifying him, he was sent to a doctor for treatment to protect against infection. The numbers and types of bacteria contained in sewage sludge are such that every precaution should be taken when an open wound is involved.

October 30—"I have been storing my best linens in a trunk in the basement and now find that a mold growth has gotten into them. Can you tell me what to do?" said a telephone voice which we classified mentally as belonging to a prim little grandmother who was obviously meticulous about her personal belongings, and badly upset by this catastrophe. Somewhat to our own surprise, we suggested that the linens be soaked in a mild chlorine bleach for several hours, laundered and stored in a dry place thereafter.

Oh, Public Relations! What divers matters come within your scope!

INTERESTING EXTRACTS FROM OPERATION REPORTS

Battle Creek, Michigan (1940)

By N. G. Damoose, *Engineer-Manager*

Comminutors. Overhauling vs. Replacement.

The comminutors began to give trouble late in the summer. Cutters and combs were not only dull but chipped badly all around. Inspection revealed rather badly worn bearings, which caused wide play and deflection in the center shafts, throwing cutters considerably off line.

Complete overhauling estimates were so high that it seemed more economical to make a trade for two new units. The new machines are much improved and far more sturdy in their construction and should be far less costly in maintenance.

Primary Clarifier Maintenance.

The settling tanks were dewatered twice during the year and thoroughly washed down. Corrosion of the collecting mechanism trusses was general and has advanced to a marked and alarming degree.

The west clarifier mechanism was scraped and cleaned with a power wire brush and painted with two coats of red lead and one of asphalt paint. The brass squeegees were found twisted and bent and in many cases completely unattached and lying on the floor of the tank. Every single bolt head had been "eaten" away and corroded to a needle-like point. Stainless steel squeegees replaced those too badly damaged to use and complete adjustment was made, using new bolts and nuts of brass.

Time did not permit overhauling of the east clarifier but new squeegees, nuts and bolts are on hand for this job.

An oil leak in the gear boxes of the driving mechanism in both tanks necessitated replacement of the oil seals. The total maintenance cost of these tanks was $79.02, exclusive of lubricants.

Decanting Sludge at Drying Beds.

The past year was the worst of record in sludge drying. Sand filter beds, while in good condition, could not function with any degree of efficiency because of the grain chaff content of the sludge. Water-logged particles of chaff seem to drop to the sand quickly and form an impenetrable cover on the sand surface of the bed. Four or five days after filling, separation took place with a 3 to 4 inch layer of sludge at top and bottom and 3 to 4 inches of clear liquor in between. By gently inserting a screw-driver between the stop planks it was possible to drain this liquor, bringing the top and bottom layers of sludge together. The moisture content of the sludge could be removed by evaporation only, since the imperviousness of the chaff cover prevented any possible drainage. The liquor drained off in this unorthodox manner inundated the surrounding area but, fortunately, drained off quite rapidly.

The lagoon beds have become nothing but holding chambers. Drainage is absolutely impossible and with the nine lagoons full to capacity, supernatant liquor overflows into the swamp which, throughout a large area, is completely saturated. The condition is such that it is considered unsafe to use the north half of the industrial rail line skirting the lagoons.

Something New in Adaptation of Sludge for Fertilizer.

All filter and lagoon bed sludge removed was sold as Battle Creek Plant Food at $5.00 per load of 3 cubic yards plus a delivery charge of $1.50. At the plant the price, in smaller quantities, was 15 cents per bushel or 2 bushels for 25 cents in 10 (or more) bushel quantities. At no time could the demand for this fertilizer be met and more than half of the orders on file for spring delivery had to be cancelled because of this shortage.

To replace an old shredder owned by the City and available for sludge grinding on a part time basis, a new and larger sludge disintegrator was purchased in 1940. This was mounted on a steel frame and direct-connected, by belt, to a 1937 model Ford, V-8, 60 h.p. gasoline engine. This home-made grinding "plant" was set on casters and made an efficient, compact, self-contained processing unit which could be moved along the piled sludge cake with comparative ease. This device considerably reduced the work and greatly shortened the grinding time. More valuable time and labor were conserved in loading by elevating the truck box and placing it in line with the grinder discharge. In this manner, almost the entire 3 cubic yards were loaded, requiring only 15 or 20 shovels to be thrown on by hand.

The entire cost of the engine, grinder, materials for building the steel carriage plus the maintenance cost amounted to $662.93. This figure constitutes the entire investment in the fertilizer "plant" to date.

The following tabulation shows all revenues from fertilizer sales as of December 31, 1940.

Year	Total Sales
1936	$ 95.00
1937	194.40
1938	770.90
1939	1,261.80
1940	1,090.70
TOTAL	$3,412.40

As indicated in the last annual report, considerable experimentation was being carried on with secondary digested sludge as a liquid fertilizer. This work has progressed rapidly and with a greater success than was anticipated. Many lawns have been covered with this fertilizer on a commercial basis, charging 1.1 cents per gallon, applied. The results obtained have been most remarkable and the effectiveness of this material has become so well known that clients are already insisting on the liquid as a substitute for the ground sludge application.

The pumping problem involved seems entirely solved by the use of a 3-inch pump which does not clog as frequently as the 2-inch unit formerly used. No delivery tank of less than 1,000 gallons capacity would be practical for commercial use and this has not yet been obtained because the plant truck does not have the capacity to haul a load of almost 5 tons.

Active promotion of this liquid plant food will be delayed until more complete digestion of sludge is assured. This is to be accomplished by an additional digestion tank, construction of which will be started in the near future. Results thus far obtained with this lawn treatment have been such as to warrant the statement that digested sludge definitely has tremendous possibilities as a liquid fertilizer.

Summary of Operation Data.

Item	1940 Average	
Population—U. S. Census (1930)	46,000	
Estimated connected	37,000	
Equivalent (by sewage analyses)	62,100	
Sewage flow—Average daily	4.11	m.g.d.
Per capita daily	111.1	gallons
Grit removal	1.31	c.f. per m.g. sewage
Volatile content	48.6%	
Primary sedimentation		
Settleable solids removal	97.3%	
Suspended solids removal	71.0%	
5-Day B.O.D. removal	34.9%	
Dry solids removed per m.g. sewage	1,721	pounds
Sludge digestion		
Raw sludge	3,133	gal. per m.g. sewage
Solids content	5.7%	
Volatile content	81.6%	
First-stage, dry solids loading	5.01	lbs. per c.f. per mon.
Transfer sludge solids	3.2%	
Volatile content	68.8%	
Volatile solids reduction	50.3%	

Summary of Operation Data—Continued.

Item	1940 Average
Second-stage, overall vol. solids red.	60.2%
Digested sludge quantity	569 gal. per m.g. sewage
Solids content	4.5%
Volatile content	63.8%
Fraction of total digestion	16.3%
Supernatant liquor	216 gal per m.g. sewage
Solids content	2.3%
Volatile content	65.7%
Gas production—per capita	1.65 c.f. per day
Per lb. volatile solids added	12.25 c.f.
Per lb. volatile solids digested	20.39 c.f.
Operation and maintenance costs (primary treatment)	
Per capita per year	$ 0.50
Per million gallons treated	$12.47

Findlay, Ohio (1940)

By Ben H. Barton, *Chief Operator*

Plant Loadings Increased by Ground Garbage.

An incinerator, installed for the destruction of screenings was found ineffective and its place has been taken by a garbage grinder. Green garbage is collected by individual or "free lance" haulers, who deliver their loads to the sewage treatment plant daily except Sundays and holidays. These collectors organize, maintain and collect their own routes and have no financial connection with the City of Findlay, as all their monetary collections are made from their customers direct. The City controls the garbage situation by an ordinance making it illegal to dump garbage at any place other than at the designated place in the sewage treatment plant. No difficulty whatever has been experienced from regular haulers, although individual citizens required regulation in delivering their own garbage.

The green garbage proved to be about 20 per cent solids and 80 per cent moisture, weighing about 5.9 pounds per gallon. Acceptance of garbage for grinding and mixture with the sewage flow has resulted in considerable additional loading upon the plant, as evidenced by the following data obtained from analyses of samples of sewage before and after the addition of garbage during the period April to December, 1939:

	Sewage Alone	Sewage plus Garbage	Per Cent Increase
5-Day B.O.D., p.p.m.	182	278	53
Suspended solids, p.p.m.	149	301	101
Population equivalent	18,080	25,743	42

During the 9-month period represented by these data, the average sewage flow was 2.262 m.g.d. and 9,418 pounds of garbage per month were ground. It is of interest to note that treatment of garbage plus sewage produced four times as much grit as when treating sewage alone.

Digestion of Garbage.

In the revision of the original design as of 1930 for the construction of the secondary devices in 1938, H. P. Jones & Co. recommended the addition of another digestion unit. After careful consideration of the cost and probable needs it was deemed advisable to postpone this additional unit until actually required. The need for more digestion capacity soon became evident with the combined addition of excess activated sludge from the secondary treatment and the garbage grinding program which was instituted with secondary treatment.

Because of the overload upon the digester, solids in considerable concentration were carried out in the overflow. The supernatant liquor is ordinarily allowed to flow into the raw sewage for treatment. When the digester is overloaded it is necessary to impound the overflow liquor in drying beds or lagoons to avoid the pyramiding of solids in the plant devices and to prevent the septic liquor from entering the secondary or biological treatment units. Here it would have a toxic effect upon the aerobic bacteria which are of utmost importance in activated sludge purification.

Solids in the overflow liquor range from 0.27 per cent to 2.65 per cent. No overflow liquor was impounded upon the drying beds or lagoons during the months of April, May, June, July and August and none was returned to the sewage in February, September and December. The disposal of overflow liquor was to a large extent controlled by the availability of lagoon or drying-bed room.

Sludge digestion data follows:

	1940 Average	
Digestion period	64	days
Raw sludge	3640	gal. per m.g. sewage
Solids content	4.82%	
Volatile content	70.7%	
Supernatant liquor	1340	gal. per m.g. sewage
Solids content	1.28%	
Returned to sewage	52 %	
Discharged to drying beds	48 %	
Digested sludge	594	gal. per m.g. sewage
Solids content	7.29%	
Volatile content	46.5 %	
Volatile solids reduction	63.1 %	

"Bio-aeration" Experience.

To provide a rest period for the overloaded digestion unit the plan of operating under "bio-aeration" has been adopted for the past two winters. This consists of operating all units normally except the return sludge pumps. Without return sludge for seeding, activation of sludge is held to a minimum and the sewage solids in solution are not removed as in the activated sludge process. This reduces the volume of sludge to be pumped to the digester, thereby increasing the detention time for complete digestion of volatile solids.

Comparative data taken during operation as a conventional activated sludge plant and under the bio-aeration plan is shown below:

	Conventional Activated Sludge (Ave. 8 months)	Bio-aeration (Ave. 6 months)
Detention time, hrs.		
Aeration tanks	7.6	7.5
Final settling tanks	3.8	3.7
Applied air, c.f., per gallon	1.0	0.8
Return sludge, per cent	25.5	0
Return sludge solids, p.p.m.	2751	0
Mixed liquor solids, p.p.m.	665	127
Per cent by volume	10.7	0.4
Suspended solids, p.p.m.		
Raw sewage	318	282
Primary effluent	90	119
Plant effluent	8	42
5-Day B.O.D., p.p.m.		
Raw sewage	323	321
Primary effluent	139	179
Plant effluent	23	55

Danbury, Connecticut (1939)

By W. M. Kunsch, *Superintendent*

Coarse and Fine Screen Operation.

Coarse screen operation resulted in a removal of 4.1 cu. ft. of screenings and grit per million gallons of sewage. On September 3, 1938, the screen was put out of service because of the great amount of wear on the main chains, sprockets, and guide wheels. The wearing of the chain and inability to keep it tight caused recurrent troubles due to its sliding off the guide channel and putting the machine out of service. New chains and sprockets were installed and the guide wheel bearings repoured. In addition, four spreaders made up of brass pipe and unions were installed to keep the chain from sliding out of its channel. These spreaders have helped greatly to prevent trouble. While this screen was out of service the sewage was diverted to the old hand-cleaned bar screens.

The fine screens continued to give very satisfactory results. Screenings removal averaged 28.1 cu. ft. per million gallons. Each screen pit was cleaned five times during the year to remove the grit and sludge accumulation. Much of the grit which is contained in the sewage is fine enough to get through the slots of the fine screen, but the slow velocity of flow permits it to accumulate at this point where it is very difficult to remove. Clearance of the fine screen seal rings is checked and adjusted to 1/32-inch each time the pits are cleaned. Also at this time the disc brushes are removed, thoroughly cleaned, and the direction of travel reversed. No new brushes had to be installed during the year. Only one new set has had to be used during the four years since the screens have been in service. Minor repairs included the installation of a new varibelt and varidrive shaft on one unit.

Digestion Tank Overhaul.

On September 12 work was begun on the cleaning and repairing of the digesters. Of the 170,000 gallons of sludge in the tank part was used for seeding the Link-Belt digester, part was stored in a settling tank for reseeding and the remainder was disposed of on the sludge beds. A heavy scum layer 1½ feet thick had to be flushed from the tank with a hose by hand.

The heating coils were found to be surrounded by a sludge cake about ½ inch thick. This was easily hosed off. Underneath this was found a thin, hard cake which was removed by scraping. The coils were then wire brushed down to clean metal. A new coil of 2 inch pipe, 172 feet long (making the fourth coil in that digester) was installed in order to increase the capacity for heat absorption. This coil was supported similarly to the old coils, by $7/8 \times 12$-inch steel rods driven into holes 5-inches deep which had been drilled into the concrete walls.

The scum and sludge breaker arms and all metal work in the tank was scraped free of rust and given two coats of protective paint. The digester was back in service on October 31 after being out of operation seven weeks.

Trickling Filter Operation.

During the 1938 season trickling filter prechlorination was stopped on September 29 when the sewage temperature had dropped to 63 degrees. Because of a large amount of pooling on the filters during late winter, chlorination was begun in 1939 on March 13. In order not to use an excessive amount the chlorine was applied at night when a high residual could be obtained with low dosage. Within one week most of the pooling had disappeared. The regular chlorinating season for odor control was begun on May 22. During the year ending June 30 a total of 32,360 lb. of chlorine was used.

Trickling filter operation continued to be highly satisfactory. High stability and low biochemical oxygen demand of the final effluent gave evidence of good oxidation. All sewage flows up to a rate of 6.5 m.g.d. were treated on the filters. Flows in excess of this were treated on the auxiliary sand filters. Distributor slots were cleaned on the average once weekly with the exception of a period in late winter when clogging of the slots by fungus made more frequent cleaning necessary. Rusting of distributor pipe and supporting rods continued to be an unsolved problem. It has been the practice to give the distributors two coats of corrosion resisting paint each fall but thus far no type of paint has been found that would withstand the action of sewage and weather. Ice formations in cold weather on the distributor supports were knocked off when necessary by the operating crew. No difficulty was experienced with ice formation on the filter stone.

Summary of Operation Data.

Item	1938–39 Average	
Estimated tributary population	25,000	
Sewage flow	5.92	m.g.d.
Quantity per capita	237	g.p.d.
Coarse screenings	4.1	c.f. per. m.g.
Fine screenings	26.0	c.f. per. m.g.
Sludge digestion		
Raw sludge	1,890	gal. per m.g.
Moisture content	3.0	%
Humus sludge	550	gal. per m.g.
Moisture content	6.0	%
Digested sludge	230	gal. per m.g.
Gas production (per capita)	0.41	c.f. per day
Operation and maintenance costs		
Per million gallons treated	$ 10.87	
Per capita per year	$ 0.96	

COMPARATIVE CHEMICAL PRECIPITATION COSTS

Operators of chemical precipitation plants may be interested in the following summaries of chemical efficiencies and costs of treatment based on data obtained at Waukegan and Chicago. The prices are based on purchases in large volume at Chicago and would vary according to the location of the plant and the amount purchased. The data are taken from a lecture given by E. Hurwitz, Principal Sanitary Chemist, the Sanitary District of Chicago, at the 1941 Sewage Work's Operators Short Course held at the University of Illinois during the week of March 10.

TABLE I.—*Quantities of Chemicals Used and Results Obtained*

Type of Treatment	Chemicals Used, Pounds per M.G.							B.O.D.	
	Alum	Ferric Chloride	Lime	Copperas	Chlorine	Sodium Silicate	Sulfuric Acid	Untreated Sewage, P.P.M.	Reduction, Per Cent
Alum	293							156	58
Ferric Chloride		162						90	63
Ferric Chloride and Lime		142	238					105	61
Chlorinated Copperas				267	38			112	52
Copperas and Sodium Silicate				154		115	15	86	69
Alum and Sodium Silicate	214					89	14	139	75

Table II.—*Comparison of Costs*

Type of Treatment	Chemical Costs, Dollar per M.G.							
	Alum $23.00 per Ton	Ferric Chloride $40.00 per Ton	Lime $10.00 per Ton	Copperas $16.00 per Ton	Chlorine $60.00 per Ton	Sodium Silicate $14.00 per Ton	Sulfuric Acid $16.00 per Ton	Total
Alum	3.22							3.22
Ferric Chloride		3.24						3.24
Ferric Chloride and Lime		2.84	1.19					4.03
Chlorinated Copperas				2.13	1.14			3.27
Copperas and Sodium Silicate				1.23		0.92	0.12	2.27
Alum and Sodium Silicate	2.50					0.71	0.11	3.32

TIPS AND QUIPS

Gadgeteers W. L. Ashdown and C. K. Cornilsen of Chicago Heights, Illinois, obtained the basic idea for their clever device for collecting a composite sample of sludge (see *Gadget Department,* this issue) at Appleton, Wisconsin, while enroute to the 1939 Annual Meeting of the Central States Sewage Works Association. Which goes to prove two things: (1) that it pays to visit other plants and (2) that you always bring back something worthwhile from your local Association meetings!

* * * * *

If the unwilling guests at Folsom State Prison in California could learn to "corrode," they might increase the problems of prison officials, who are troubled by the efforts of digester gas to "escape" through the sides and roof of the steel gas-holder at the sewage treatment plant of the institution. Corrosive pitting of the interior of the holder led prison officials to seek assistance from the "Corner" and our investigation of the problem revealed some information which may be useful elsewhere.

It was recommended first that the gas be passed through iron-sponge scrubbers to reduce the hydrogen sulfide content, which treatment should measurably reduce corrosion in the holder as well as in gas utilization equipment and appurtenances.

We were unable to recommend any protective treatment for the inside of the cover, however, until excellent advice was obtained from chemists of a large midwestern utility company. This company gives the interior of all of its gas storage tanks an annual treatment of Socony-Vacuum Black Oil "H," applied when the inside of the holder is dry (a day when the outside air temperature is well above the gas temperature). The lower sides of the holder are treated by floating a quantity of oil inside the tank, then pumping water beneath the cover to raise the level. The under side of the roof and the upper walls are treated by spraying the oil through a perforated pipe (Fig. 1), after the oil has been heated to 140° F. The spray pipe is S-shaped to afford the desired coverage and is drilled with Number 60 holes in the top. It is inserted in a small hole in the roof (which is plugged when the holder is in serv-

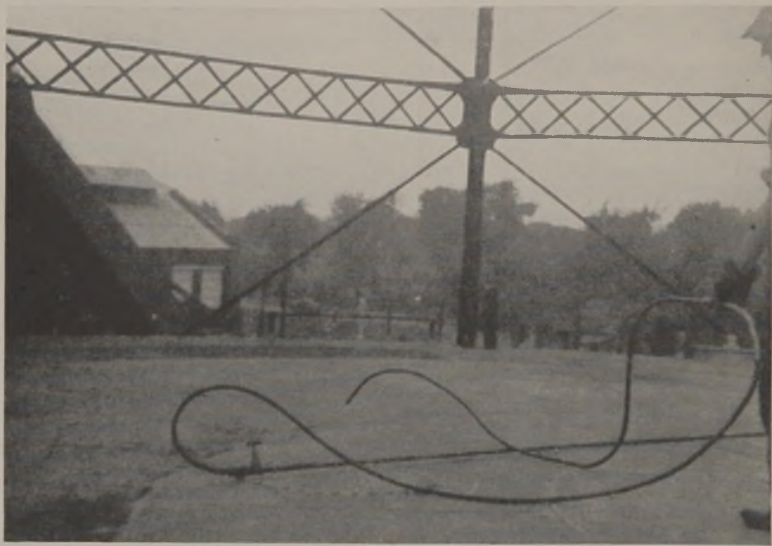


FIG. 1.—Oil applicator for treating interior of gas-holders.

ice) and revolved until a large circle is treated. A number of such holes may be required for holders of large diameter. The utility has found the oil treatment to be superior to the paints formerly employed and has been using the above method since 1937.

* * * * *

"The operator of a small sewage works has not what one might call a spectacular job; the fact that a works does not attract the attention of the public is in itself evidence that it is being efficiently managed, but he does have the satisfaction of knowing that to him has been entrusted the responsibility for maintaining one of the essential public health services."—*H. H. Stanbridge, Member, The Institute of Sewage Purification, England.*

* * * * *

Contributing to the Michigan Sewage Works Association *Bulletin,* Thomas Powers of the Waste Disposal Department of the Dow Chemical Company recommends the following method of finishing laboratory table surfaces:

> An excellent finish for laboratory benches and tables can be secured by the formation of a resin produced by the reaction of furfuryl alcohol and sulfuric acid directly on the surface to be covered. Producing an extremely hard, glossy, black finish, this resin is resistant to the action of acids, alkalies, organic solvents, heat, and mechanical shock or abrasion.

The surface, which may be wood, soapstone, masonite, or transite, should be thoroughly clean and dry. Using a swab of cloth or cotton waste a thin coating of furfuryl alcohol (technical grade) is applied. The alcohol is allowed to stand for a few minutes to penetrate the surface; and then, using another swab, a coating of dilute sulfuric acid (one volume of technical sulfuric acid to four of water) is applied in the same manner and allowed to dry. Another coat of alcohol is then applied. The treatment is continued, allowing time to dry between applications, until the surface is satisfactorily covered.

It is advisable to wear rubber gloves during the application, as the reaction proceeds with some violence, generating heat which may be sufficient to ignite the swab.

This method of finishing laboratory tables was suggested in a bulletin issued by the Quaker Oats Company, and was developed in the Analytical Laboratories of the Dow Chemical Company.

* * * * *

A practical use for another by-product of sewage treatment plants may result from studies at Detroit, Michigan, where cement has been successfully manufactured from ingredients including about 17 per cent incinerator ash. Although several adjustments appear necessary, this method of disposition of ash may eventually prove workable.

At present, all of the grit removed at Detroit is not incinerated. Chief Engineer Arthur Morrill very completely expressed the effects of the by-pass of some raw grit directly to the lagoon in his statement that, "the sea-gulls around the ash lagoon are not attracted there by ashes."

* * * * *

R. M. Dixon, Superintendent of sewage treatment at Dallas, Texas, is confronted with the task of developing an ordinance for regulation of industrial waste discharge to the sanitary sewers. Control of paunch manure and other wastes from packing plants is the major problem. Superintendent Dixon will appreciate any copies of ordinances which are effecting successful regulation at other cities.

* * * * *

Almost every week brings an announcement of another school or short course for sewage works operators, indicating a wide appreciation of the value of higher education in our profession. The following sewage school cheer, written some years ago for *The Digester* of the Illinois Department of Public Health, may be more apropos at this time:

Screen it! Settle it!
Let the bugs gnaw!
Treat that sewage—
Raw! Raw! Raw!

CONCERNING PRIORITIES

After difficulty had been encountered in obtaining equipment repairs for use in several Illinois sewage treatment plants because of priority restrictions, the State Sanitary Water Board made inquiry regarding the procedure in obtaining prompt delivery of such parts in emergencies. C. W. Klassen, Technical Secretary of the Sanitary Water Board, submits the following information contained in a letter from Mr. Reavis Cox, Assistant Director, Division of Civilian Allocation, office of Price Administration and Civilian Supply, 2501 Q Street N. W., Washington, D. C.

Any of the municipalities in your state may obtain priority ratings for the maintenance and repair of sewage treatment plants by filing Preference Rating Application Form PD–1 with the Office of Production Management. This, you will note, covers only the maintenance and repair of these plants, and will take care of some of the municipalities to which you refer.

Your second proposition, namely, the supply and equipment required for the operation of sewage treatment plants, is now receiving our attention. If any of your plants are having difficulty in obtaining such supplies, please have them advise this office and they will receive immediate consideration.

With respect to chlorine, it appears that supplies required for public health uses as in water and sewage works are considered equally as important as the demand for defense purposes. If difficulty is experienced in obtaining chlorine, the State Department of Health should be contacted and assistance can be rendered in bringing the shortage to the attention of the proper authorities so that delivery will be expedited. By avoiding hoarding of excessive supplies and by promptly returning empty containers, plant operators can aid materially in the maintenance of an uninterrupted source of supply for all purposes.

PROMPT RETURN OF EMPTY CHLORINE CYLINDERS WILL AID NATIONAL DEFENSE

It is of utmost importance that there be no delay in the return of empty chlorine cylinders to the chlorine manufacturers in order to expedite chlorine shipments for national defense needs and for use in water and sewage works. The following is extracted from a letter received from A. B. Chadwick, Chairman of the Alkali-Chlorine Committee of the Army and Navy Munitions Board:

Your attention is directed to the urgent need for prompt return of chlorine cylinders so that all users of chlorine serving national defense and those users responsible for sewage and water treatment may be properly supplied with chlorine. Many thousands of cylinders are required to serve sewage and water treatment. The number of cylinders owned by chlorine producers which are regularly in this service has in the past proven to be sufficient to supply these important sanitation plants.

Recently orders for shipment of chlorine to such sanitation plants have increased, no doubt because fear of a chlorine shortage has caused some users to accumulate stocks of chlorine. This has resulted in increasing the number of cylinders which are, at the present time, at sewage and water works. Any increase in demand for chlorine in small cylinders for stock is unnecessary as the chlorine industry is well able to supply all the needs of sewage and water works, providing empty cylinders are promptly returned.

We solicit your assistance in bringing about a reduction in this abnormal demand for chlorine in small cylinders and in urging upon the members of your Association to return small cylinders promptly to the chlorine producers' plants. Every empty cylinder that can be returned now, can be filled with chlorine and reshipped promptly to points where chlorine is needed.

In addition to the need for bringing about a better turnover of cylinders, there are other reasons which dictate prompt return of cylinders. These are:

1. *Safety.*—Accidents have occurred when cylinders have been permitted to lie around exposed to the elements with a small amount of chlorine in them. Return of empty cylinders must not be put off.

2. *Retest of Cylinders.*—I. C. C. Regulations, Section 303, effective January 7, 1941, under the penal statute known as the Act of March 4, 1921, requires that cylinders be retested regularly by producers.

This Committee is recommending to the members of the chlorine industry that each producer attach a tag to each cylinder, or stamp each of his invoice as follows:

"This cylinder is needed for national defense and sanitation."

"You will aid your country and yourselves by returning it to the owner as soon as it is empty."

"Do it now! Do not delay!"

GADGET DEPARTMENT

A Compositing Sludge Sampler

Submitted by

WALTER ASHDOWN, *Superintendent,* and C. K. CORNILSEN, *Chemist,*
Bloom Township Sanitary District, Chicago Heights, Illinois

The commonly provided quick-acting sampling valve on the discharge side of sludge pumps is often untidy, a source of odors and usually not capable of furnishing a satisfactory sample. The simple and economical arrangement illustrated in Figs. 1 and 2 has eliminated

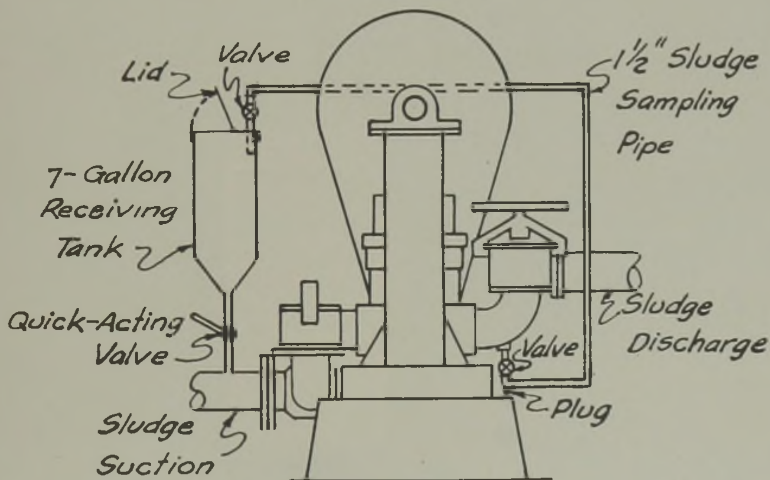


FIG. 1.—Sludge sampler employed at Chicago Heights, Illinois.

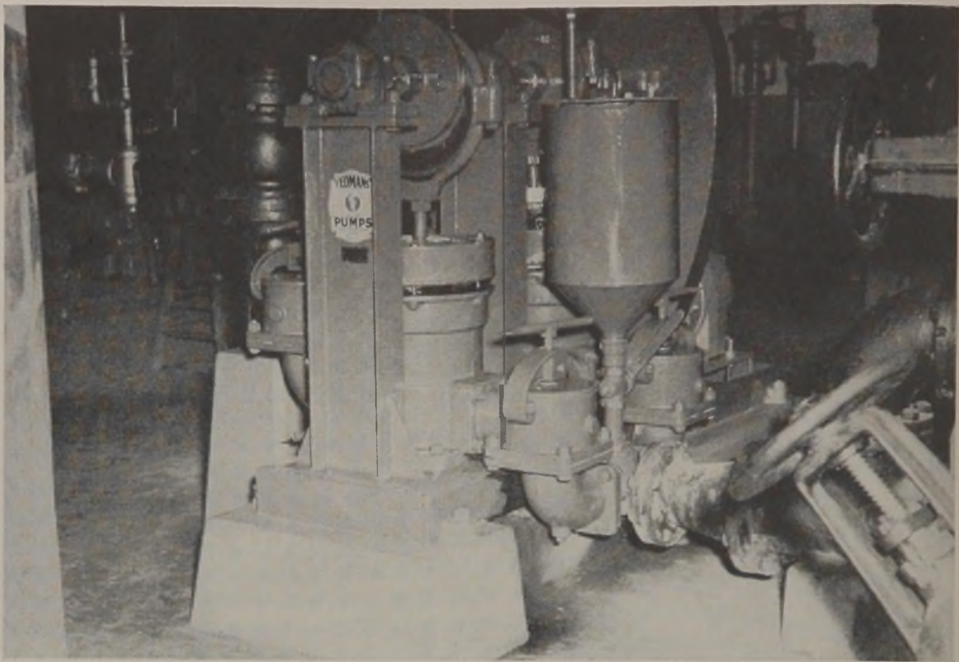


FIG. 2.—Sludge sampler employed at Chicago Heights, Illinois.

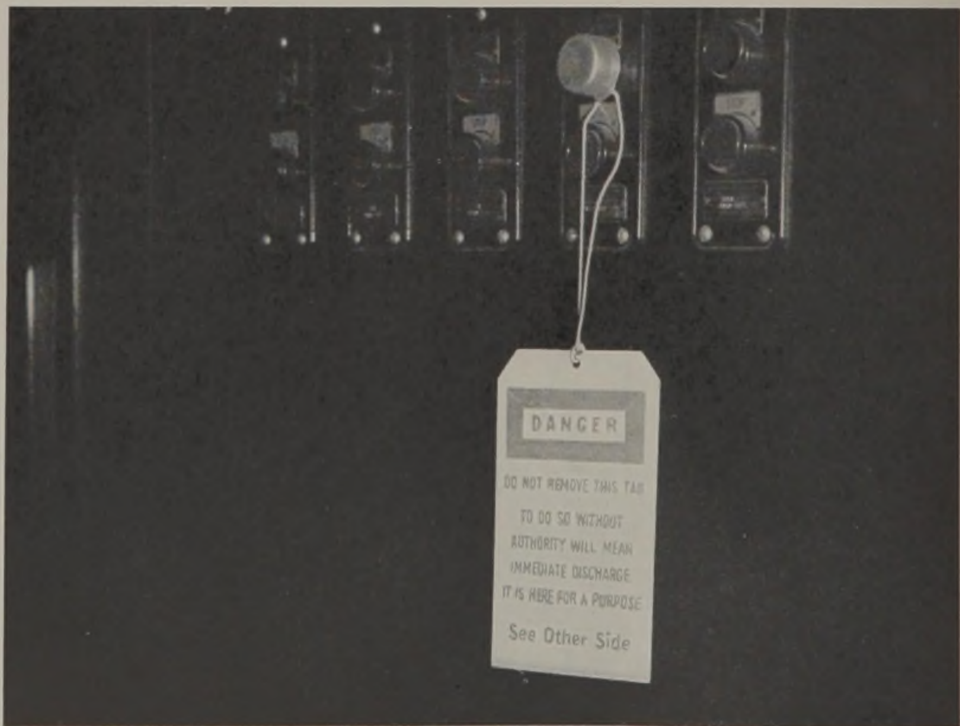


FIG. 3.—Safety "Tag-Out" used at Detroit, Michigan.

the above disadvantages in the treatment works of the Bloom Township Sanitary District where positive displacement sludge pumps are used.

The sampling piping is so connected that a small spurt of sludge is discharged to the sample receiving tank at each stroke of the pump piston, control of the jet being afforded by a valve in the piping. When the sludge meter registers 500 gallons, the sample is stirred and the desired portion removed. The receiver is then drained by opening the valve to the suction line and the cycle repeated.

The receiving tank is fitted with a tightly fitting cover so that splashing and odors are confined.

A Safety "Tag-Out"

Submitted by

Clyde L. Palmer, *Plant Supervisor,*
Detroit, Michigan

As a safety measure in the Detroit plant, the tag system is used to prevent starting of an item of equipment which is undergoing repair or servicing. The gadget illustrated in Fig. 3 has been found to render an almost "fool-proof" tag-out.

The tag is attached to an aluminum, one-teaspoon measure which fits snugly over the switchboard starter button and, when in position, makes it impossible to push the starter button erroneously or accidentally. This tag-out is most conspicuous and effective.

Wind Direction Indicator

Submitted by

F. Wayland Jones, *Superintendent,* South Plant,
Stockton, California

Proximity to residences necessitates carefully maintained records of wind direction at Stockton's South Plant, as defense against unjustified complaints of odors. The attractive device shown in Fig. 4 answers the above purpose and draws interest and comment by plant visitors.

The base of the wind gauge is made of 5-ply, waterproof wood, cut in a circle of 12 inches diameter and marked off into the points of the compass. A ¼-inch S.S. floor flange is bolted to the center of the base, into which there is screwed a ¼-inch by 4 inch S.S. pipe nipple. The revolving indicator has a sail-boat on one end and an arrow with pointer on the other, and is mounted on a vertical rod of ¼-inch outside diameter copper tubing which fits into the ¼-inch S.S. pipe base. A small ball bearing and a few drops of transformer oil in the base pipe permits the indicator to revolve freely in the slightest breeze.

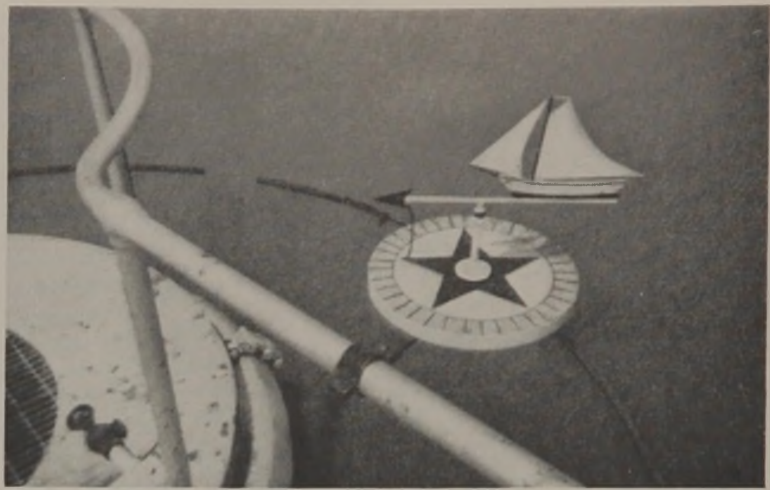


FIG. 4.—Wind gauge used at South Plant, Stockton, California.

At Stockton, the wind gauge is mounted on the rail of a clarifier where the movement of air is unrestricted from all directions.

DISCUSSIONS AND REPERCUSSIONS FROM PENNSYLVANIA *

Operating Hazards and Safety Measures at Sewage Treatment Plants

QUESTION.—*In case you use a gas mask canister only part time, what is the life of one of them?*

E. W. GILLILAND (*Chemist, Mine Safety Appliance Company, Pittsburgh, Pennsylvania*).—There really isn't any way to gauge the life of an individual canister. The only way to be specific about it is that so long as it protects the individual, it is still in condition to use.

In the case of chlorine, or any of your irritating gases, you cannot do that with an all-service canister. The all-service canister must be used for a period of only two hours. The reason why we specify that is this; under the most adverse conditions, the drying elements that we have in this canister will be suitable for that period of time. You will get no carbon monoxide through the canister because the moisture will be removed. Beyond that time limit, we cannot guarantee it. So, in the all-service canister, we have developed a timing device which indicates the amount of time that the canister has been used. There is a small dial which is activated by each respiration, and in a normal two hours' use, the dial makes one entire revolution.

* From Report of Annual Meeting of Pennsylvania Sewage Works Association, held at State College, June 26–28, 1940.

Question.—*In other words, you can use it for a half hour at one time, and then at a later time, use it for another half hour, and then later on, use it for an hour. Is that correct?*

Mr. Gilliland.—Yes, you can use it for five minutes, ten minutes, or any length of time you wish, but over a period of two hours altogether, the canister is entirely saturated.

There is another requirement in connection with the use of this canister, and that is, they should be replaced at least once a year after the date the seals have been removed. The reason for that is this; we have a check valve on the top and one on the bottom, and they are designed to prevent air from getting into the interior of the canister. The top valve is exposed to the normal air, and these dryers are going to be affected, so we recommend that the canisters be replaced within one year from the date the seals have been broken, whether or not they have been used for the two-hour period.

Where you have gases that are readily noticeable, particularly through irritation to the eye or the nose, or irritation to the respiratory system, the canister can be worn until those gases are noticeable, or when the breathing resistance has risen to the point where it is uncomfortable. In other words, we term it the "break" of the canister. There may be ½ per cent of gas entering the bottom, but when it starts to break, only a few parts per million can go out the top, because most of it may be in the lower portion of the canister. The top is still comparatively good. So, the individual has an opportunity to get away from that area even if the canister does start to break.

Question.—*You mean that the canister might be good for five or ten years, providing the seal has not been broken, is that correct?*

Mr. Gilliland.—Yes, in fact, in my own experience, we have kept them in mines, stored underneath the ground, for a period of over seven years, and the protection was still there. We have been particularly concerned with the all-service canister.

Question.—*Is that particular type as good as the mask protector type?*

Mr. Gilliland.—This mask type is much more effective in service, that is, as to the number of hours or minutes, but as to the relative efficiency, no. The cartridge type unit will absorb the gas for a period of time, and I might explain it this way; if you take a sponge an inch in diameter, that sponge will absorb only a cubic inch of water, and it will absorb it completely. If you take a sponge three inches in diameter, it will absorb five cubic inches.

Question.—*Wouldn't that type be more advantageous in mines than this type?*

Mr. Gilliland.—This type of canister for mines is primarily for rescue work. The miner himself carries what we call a "self-rescuer," which is this type, and he carries it on his belt.

We are concerned primarily with one thing, and that is carbon monoxide. You see, he doesn't have the opportunity to carry a piece of equipment that contains oxygen, but in the event that the air has been contaminated, he can use this self-rescuer and get away. He merely takes this unit from his belt, pulls the lid off, and inserts the nose clip, and breathes through the chemical. That chemical removes the carbon monoxide and he can get away and will have an opportunity to get to a place where there is fresh air. The service life is guaranteed to be 30 minutes. We have operated them as long as one and one-half hours, but they are guaranteed to last at least 30 minutes. A man can go a long distance in 30 minutes' time, providing the passageway is clear.

Question.—*Is the miner compelled to carry the canister?*

Mr. Gilliland.—That depends upon the organization. Today the insurance rates vary with respect to the safety precautions taken by the organization. Your insurance premium, industrially, will be lower if you have a low accident record. Some mines insist 100 per cent upon its use, and other mines do not insist upon it. I might state that after the serious mine explosion in West Virginia during the early part of this year, it certainly caused the mining companies to require their men to wear self-rescuers.

Question.—*What percentage of those men who were killed would have been saved had they been equipped with self-rescuers?*

Mr. Gilliland.—Frankly, I do not know. There is the question of how much oxygen there was in the air. There may be a gas explosion, and it isn't so much the gas that is causing the real damage, but it is the coal dust that is kicked up. That is what reduces the oxygen materially. If it is a gas explosion, the chances are that the man is going to get out, providing, of course, he has some sort of equipment, but in a coal dust explosion, it is a lot more dangerous. However, there may be an area, in certain galleries that he has to go through where it might be bad, but if he has a pretty good start he can keep himself going pretty well with one of these self-rescuers.

Of course, we know there have been a great many cases where lives have been saved through the use of the self-rescuers. In one case in particular there happened to be an explosion in a mine, and one man came out and stated that his buddy became frightened and the self-rescuer was knocked from his mouth. Another fellow standing there heard him tell about it and he grabbed the self-rescuer from this man's face, put it on and entered the mine and found the other fellow and dragged him to the entrance of the mine, where he could get some fresh air, and consequently saved his life. We know of a few definite cases like that, which only go to prove that it is a good precaution.

Question.—*Getting back to the sewage treatment plant. What would you say as to the cost of a reasonable amount of equipment for a sewage treatment plant? In other words, how much would it cost for a reasonable amount of equipment, if that question is not too broad?*

Mr. Gilliland.—Of course, that would be governed entirely by the size of your operations.

I might point out that it is purely an insurance proposition, in the matter of not only saving human lives, but in the protection of your equipment. When you have an investment in men and in equipment, what you want to know is how much is it going to cost you to replace that equipment or those men. Now, how philanthropic are you with respect to the welfare of your men? You take a device like this (respirator). Roughly speaking, I would say it would cost in the neighborhood of $150 or $200. That is a lot of money for a sewage treatment plant. In a municipality, usually the Fire Department, or some industrial plant, or some swimming pool nearby, may have some equipment like this which may be available, and the thing to do there is to find out just where you can put your hands on one quickly.

Question.—*Let us divorce for a moment the expensive equipment, and let us talk about the smaller units you have there, on the table.*

Mr. Gilliland.—All right, how frequently does an individual have to concern himself with good lighting in an emergency. Do you have flashlights? Do you have hand lamps? How satisfactory are they, particularly when a man has to carry a light and perhaps go over a ladder or upstairs in case of an emergency? He has to have a light in his hand if the equipment consists of a flashlight or a hand lamp. Now then, if he has a light of this character (electric lamp fastened to front of cap) it is already in position to furnish him illumination, and at the same time, he has the free use of both of his hands.

Let us say that you have a problem of going inside a tank for the purpose of cleaning that tank. What do you know about the condition of the atmosphere down in that tank? Do you want to blow compressed air into that tank over a long period of time? Do you know whether or not it is necessary to flush that tank out two or three times? Possibly there is some gas still being liberated from some sludge that still may remain there. Do you want to be responsible for putting the men down in that area without being certain? In order to be on the safe side, you should have this type of equipment right here (Explosimeter).

Question.—*Assuming that we are going to have all of these things here, roughly, how much would it cost? Would you say around $200?*

Mr. Gilliland.—Anywhere from $200 to $500 would give you a group of material with which you could detect gas readily.

Question.—*In other words, $300 would buy a sufficient amount of material for the small sewage treatment plant?*

Mr. Gilliland.—Yes, you would have a good serviceable group of instruments in your plant.

Question.—*After that indicator has been exposed, would you have to use a new tube the next day?*

Mr. Gilliland.—I have personally made eight tests with one tube. Of course, that was not over a period of days, but those tests were made during one single day. The reason is this; the color fades on your carbon monoxide detector unit. The chemical is being destroyed, and there is a limitation, I might say. For instance, temperatures in the neighborhood of a little below freezing influence the sensitivity to some extent. One must be a little cautious about that. However, printed instructions are supplied with the various types of equipment.

QUESTION.—*What would be the cost of the warning device you had, with the sound mechanism, where you might have sewage gas in galleries?*

MR. GILLILAND.—Well, for the average installation of a combustible gas alarm, with one sample line, I would estimate it would cost in the neighborhood of $600 or $800. Of course, you are concerned there with the protection of your equipment. It gives you a constant warning. That includes the alarm.

QUESTION.—*How long will that last? Would you have to replace it in a year or two?*

MR. GILLILAND.—You have a filament which will last in the neighborhood of about two months. Those filaments will have to be replaced, but your other mechanism and electrical wiring, and control, etc., are permanent. The only thing you are concerned with is the actual unit itself, due to the continuous exposure to high temperatures. What I mean is it is entirely satisfactory for natural gas, but not for acetylene or hydrogen gas.

We have many installations where they only have one or two of these small lamps, and they merely plug them into the light socket. With the battery type, normally we don't require the company renting these to pay the rental when the mine is not working. In other words, our income from rentals was seriously curtailed last Spring during the strike. We had the investment, but no income. However, the batteries were still good. The batteries will remain good even if they are inactive over a long period of time.

Plant Maintenance Problems

MEMBER.—I just wish to make a comment, and that is this: When you go into a sewage treatment plant and look around and find everything clean and well painted, it is almost a waste of time to go over the mechanical equipment, because if the plant is clean, you are pretty sure that the equipment will be in the same condition.

H. E. MOSES (*Pennsylvania Department of Health*).—Last week I had an occasion to go to the plant at Mount Alto, and the thing that impressed me was that every valve and every piece of equipment in the pipe gallery and pump room is very definitely marked as to what it is, so that an outsider coming into the plant can easily understand what a certain piece of equipment is for and what each and every pipe is for and it certainly must help the operator in the operation of that plant. I think it is something that could be adopted in other plants.

It seems to me that there would be no doubt in the operator's mind as to what a certain valve does when he opens or closes it, and no doubt as to what a certain pipeline is for.

Roy L. Phillips (*City Engineer, Meadville, Pennsylvania*).—We have adopted the American Society of Mechanical Engineers' paint scheme for our plant. The different lines are painted certain colors. There is such a standard, and while it may not apply 100 per cent to the sewage treatment plant, yet it does fit well enough so that you can distinguish lines easily. We have adopted that scheme, and we think it is a fine way to define pipe lines, and also it helps you out in regard to the interpretation of the valve uses.

I should like to tell you about a little experience we had with what we thought was valve trouble. We had two stoppages in our primary settling tank this year, which were very, very annoying. It happened that a W.P.A. worker had broken the handle of his round pointed shovel, and he dropped the broken shovel into the settling tank, and it fell in such a position that it interfered with the suction line to the sludge pump. Under normal circumstances, it was all right, but when you started to pump, it would pull that round pointed shovel right up against the end of that valve. And believe me, we had a hard time trying to find out what was wrong.

M. D. Smith (*Laurelton, Pennsylvania*).—Have any of you gentlemen come to any conclusion or standardization as to what is the best type of paint to use on concrete walls of settling tanks? Or, as a rule, don't you paint them?

F. G. Diefendorf (*Erie, Pennsylvania*).—I might say that when we built our plant, we painted the inside, up to the water level, with Inertol.

In regard to maintenance, that is, greasing and oiling, I would like to state that a number of years ago we introduced a schedule of greasing and oiling that has proven very effective. The operator on the morning shift each day is required to grease and oil all of the operating mechanism which is being used constantly. And then every Monday morning we have two men go around together and they look at every piece of equipment and check the grease and oil in all motors and speed reducers and every grease cup or oil hole, in order that everything is greased and oiled properly. Undoubtedly, we use more grease and oil than necessary, and I will admit that, but we do save considerable money on repairs. By having two men go around together, we don't miss anything. What one may overlook, the other one will catch.

President Olewiler.—On the subject of grease and oil, I think that most of us will agree that they are the most inexpensive things we can use, taking into consideration the cost of repairs. I think the oil that we use costs us 13 cents or 14 cents a gallon, when bought in fairly large quantities, and when you can get anything as reasonable as that, it is not going to cost you a whole lot of money.

A year or so ago, Mr. B. F. Hunter, Research Engineer of the Gulf Refining Company, Pittsburgh, Pennsylvania, gave a very interesting paper on the subject, "Lubrication." At that time, he pointed out that it wasn't so important as to how much oil you use, as it was to get that oil into the right place.

I would like to ask Mr. Diefendorf a question. In the painting of your tanks, was it done before the tanks were filled?

Mr. Diefendorf.—We have to get the tanks completely dry, and also thoroughly clean in order to put on the Inertol. All of the grease has to be removed. The largest part of the work is cleaning the tanks, and the iron work also. The Inertol is put on the iron and steel below the water line.

T. R. Hazeltine (*Butler, Pennsylvania*).—In the majority of cases, I don't see any reason for painting concrete. There is nothing going to happen to it below or above the water, but in a wet well, where there is poor ventilation, the concrete has to be painted to prevent disintegration. However, in an open settling tank, I don't see why the concrete should be painted at all.

President Olewiler.—If you are going to paint a wet well, I don't see how you are going to do it.

Mr. Hazeltine.—The only thing is to give it a very good coat of paint before you get it wet.

I will be able to tell you more about it after awhile. We built a new pumping station in Butler last year, and we painted it with an emulsified asphalt entirely above the sump. That was only six months ago.

F. S. Friel (*Philadelphia, Pennsylvania*).—I think there is justification for painting the settling tank where there is apt to be some damage at the frost line. The purpose of the paint is to seal up the pores in the concrete. We find that most of the disintegration of tanks occurs at the freeboard line.

Now, as to the type of paint, I agree with Mr. Diefendorf entirely when he says Inertol paint is the best. I have had some very sad experiences using emulsified asphalt.

C. H. Young (*Pennsylvania Department of Health, Meadville, Pennsylvania*).—Why would you want to paint the tank below the water surface?

Mr. Friel.—Where you have freezing weather during the winter, you are bound to have a movement of the ice up and down along the side walls, which will have a sort of sandpapering effect and it will have a tendency to scrape the paint off, so it should be painted each year. Most of your disintegration occurs at that freeboard line.

We have also made a practice of painting tanks from six inches or a foot below the water level, up to the top of the tank—just a band of paint around there.

H. M. Herr (*Hershey, Pennsylvania*).—We have had a similar experience in the use of Inertol in connection with painting our sedimentation tanks at the sewage disposal plant, and we have had very good results. It has been in operation since 1923. We painted the entire tank from the bottom to the top with Inertol about 15 years ago. We used black Inertol. The concrete is in a perfect state of preservation from the top to the bottom. Of course, they are twin tanks, and they may be lowered or raised to different heights, and are in all kinds of weather. Whether the temperature has any effect or not, I don't know, but I do know that the condition of the concrete is perfect.

G. H. Boone (*Norristown, Pennsylvania*).—Our plant has been in operation since 1931, and the tanks were painted with Inertol. We look at the tank very carefully each time we take it down, and we haven't so far found it necessary to repaint it. The old paint is still in good condition.

Just one more thing, in regard to the painting of glass covered beds (we call them green-houses), I used five different kinds of aluminum paint for experimental purposes, and I found that the cheapest paint we used held up the best. The name of that paint is Arco, and it is made in Cleveland, Ohio.

Mr. Swinehart (*Pottstown, Pennsylvania*).—In Pottstown, we have all of the inner walls painted with a very light ivory, if you choose to call it that. In reality, it is a mixture of colors. We paint it up six inches from the floor with a light green border around the bottom.

G. L. Wirtz (*Atlas Mineral Products Company, Mertztown*).—In New Jersey there is a plant serving ten towns that is very well painted and kept up. They have used light buff paint on the walls, and the floors are also painted. They do something there that I have never seen in any other plant. In order to keep those floors looking nice, they have put down rubber runners between the pumps and machinery. If anybody steps off that runner, somebody tells them about it. But it does help to keep the plant looking nice.

G. M. Crawley (*State College, Pennsylvania*).—I would like to know how you keep the paint on.

President Olewiler.—Our experience has been that you keep putting it on.

Does anyone know how to keep paint on a cement floor?

I think if you put rubber runners down, and if it is necessary to pull a pump apart and you have a little trouble with it and sewage is spread all over everything, it is a job to keep it clean underneath the rubber runners. You have to take them out and scrub them.

Let us go to the machinery in the plant. Now, let us talk about bearings. Do you do anything about bearings? Do you let your shafting go until it is shaky? What do you do in your plant?

M. D. Tark (*Philadelphia, Pennsylvania*).—I would like to say a few words about lubrication. Every manufacturer of equipment puts on their equipment a name plate telling what lubricant should be used on that particular piece of equipment. It is very important to follow those instructions. You can't use every kind of oil and grease. If you do, it is bound to result in a tremendous amount of wear. You cannot use winter grease in the summertime, or vice versa.

I think that the electrical equipment in the plant gives you more trouble than anything else, and, it is important to keep your contacts clean. Any operator looking after those little things will save himself a lot of work and trouble.

PRESIDENT OLEWILER.—We have had switches in oil that continually burned out. I wonder if you have had the same trouble. How often do you look at them? Recently we went to the electric company and secured a quantity of transformer oil to keep them in working order. We suspected that the oil was getting bad. However, we are taking the lid off and looking at them more regularly than before.

C. S. HIBSCHMAN (*Borough Superintendent, Ambler, Pennsylvania*).—When an operator asks for a particular kind of material or repair parts for replacement, does he keep a record showing what that particular material is wanted for, so that you do not spend more money for that thing than you should spend? For instances, an order may come through for packing for a pump. Perhaps the purchasing department bought some, but it was not the kind of packing that was specified. The result was that in about three weeks' time that packing had to be replaced, whereas if they had purchased the kind that was specified, they would have had six months' service from it.

I want to show the necessity of keeping an accurate record of just what these things are used for, and the importance of getting just exactly what is needed for a particular type of equipment.

PRESIDENT OLEWILER.—I am very glad to say that we do not experience any trouble of that kind. We have a good council down there, and if we go to them and tell them that we want a certain thing, and the purchasing agent buys something else, we can go back and say that we do not want that particular kind of material.

We have a special reason for wanting certain things, and we insist that the purchasing agent get them for us, and they will back us up. We generally get what we ask for. They have been quite liberal in what they will allow us, because they know that in the past we have been very reasonable in our requests.

HAPPY SHORT STORY

Rator's sluggish,
Can't do work.
Reads, "Convention
In New York."

Hops on train—
There he goes!
Now he's back
Upon his toes!

EDITORIAL

IRON IN SEWAGE

A complete book would be required to cover adequately the subject of iron in sewage. Iron is probably of slight significance in normal domestic sewage, but when the concentration is increased considerably, by pickling liquor, rouge residues, or mine wastes, the properties of raw sewage may be greatly changed, and iron may constitute a troublesome problem in sewage treatment.

Most of the detrimental effects of iron in pickling liquor or mine wastes are well known. Streams are frequently made acid, followed by reddish discoloration by precipitation of ferric hydroxide, and depletion of dissolved oxygen by oxidation of iron. The normal flora and fauna of streams are destroyed, and the bottom is covered with an iron oxide sludge which may require dredging. If the stream becomes deoxygenated, the water may turn jet black due to formation of ferrous sulfide.

In sewage treatment plants, iron-bearing wastes add to the sludge load, require air for oxidation, and may clog filters. One of the most insidious evils of iron in sewage is the clogging of diffuser plates in activated sludge plants. The ferrous iron oxidizes to ferric hydroxide in the pores of the plates, which must be cleaned with sulfuric acid and sodium dichromate to remove the precipitate and restore the plates to approximately their original porosity.

Considerable difficulty of this type has been encountered in The Sanitary District of Chicago at the Calumet Treatment Works, where the iron content in 1936 averaged 17 p.p.m., with peak hourly concentrations of several hundred parts per million. Plates clogged within a few weeks after cleaning and motor temperatures rose to undesirable levels. Iron wastes were removed from the sewers by diversion of pickle wastes to the river, although pickling wash water continued to be discharged to the sewer. After this diversion was in effect, the average iron content dropped to 5 p.p.m. in 1938 and averaged 4 p.p.m. in 1939 and 6 p.p.m. in 1940. The content is increasing steadily in 1941 because of greatly increased industrial activity.

At the North Side activated sludge plant, to which practically no iron-bearing wastes are tributary, the iron content averages only 3 to 4 p.p.m., and no trouble has been encountered with clogged plates.

Trouble similar to that at Calumet has been reported elsewhere. Large concentrations of iron are present in the sewage at Cleveland, although mostly in the Southerly area, where pre-aeration is practiced ahead of trickling filters. The sewage at the Southerly Works contained an average of 150 p.pm. iron in the year 1939. This excessive amount caused very serious clogging of diffuser tubes. The Easterly sewage contained an average of 17 p.p.m. and Westerly 15 p.p.m

Other iron troubles have been reported at Fostoria, Ohio, where enormous amounts of iron at one time practically put the trickling filters out of business. Worcester, Mass., has long had large amounts of iron in the sewage, although the trickling filters have fortunately not been plugged by iron hydroxide.

Many additional instances of trouble from iron could probably be found. It is rather paradoxical that iron is added to sewage in one well-known process, when removal of iron is so earnestly desired in many sewage works. However, the amounts added are low and uniform, whereas the worst trouble from uncontrolled iron discharges is caused by excessive temporary concentrations.

The content of iron in activated sludge is also important, inasmuch as the iron may be reduced in the settling tanks and re-oxidized at the plate surfaces. Therefore total iron concentration as well as peak discharge is important.

The problem of disposal of iron-bearing wastes by the steel industry is so vast and complex that we can only mention here the efforts that have been made during the past several years by Dr. Hodge to find a feasible recovery process for pickling wastes. A discussion with Dr. Hodge of his work at Mellon Institute discloses the difficult and expensive procedures now necessary to recover ferrous sulfate. Many chemists are working on the problem in the U. S., and in England, Belgium and Germany. The main difficulty is expense and limited market. However, some more promising recovery process may turn up because of this intensive and far-flung study of an apparently universal problem in sewage treatment.

The problem of disposal of pickling wastes has always been a thorn in the flesh of the steel industry. No large market has so far developed for ferrous sulfate, and sintering to ferric oxide is not profitable except on a very large scale.

The innumerable patents on processes for disposal of pickling wastes indicate the long study that has been given to this problem. It is fortunate that Dr. Hodge was engaged by the Iron and Steel Institute to review all known patents and processes, and to investigate new methods. He will deserve the gratitude of many sewage works operators and sanitary authorities, as well as the Iron and Steel Institute, if he succeeds in his efforts to solve this old and troublesome problem—the disposal of iron pickling wastes.

F. W. M.

FEDERATION OF SEWAGE WORKS ASSOCIATIONS

Second Annual Convention

New York City

Oct. 9-11, 1941

The final program for the New York Convention has been released, and special features of this great meeting have been announced by Morris M. Cohn, *Chairman* of the Publicity and Attendance Committee.

The Final Program

Thursday, October 9th

Registration
Manufacturers' exhibits open for inspection

Introducing the Second Annual Convention of the Federation of Sewage Works Associations	President C. A. Emerson
Greetings from New York City	Hon. Irving V. A. Huie Commissioner of Public Works New York City
"Operating experiences in New York City"	Richard H. Gould
Luncheon period	
"Design of sewage treatment plants to facilitate operation"	Stuart E. Coburn
"Effect of load distribution on the activated sludge process"	Gordon M. Fair and Jack E. McKee
"A laboratory study of the Guggenheim biochemical process"	Earle B. Phelps and John G. Bevan
"Utilization of sludge gas in moderate sized treatment plants"	George Martin

Evening smoker and entertainment

Friday, October 10th

"Operation of sewage treatment plants and sewerage systems from the standpoint of national defense"	Warren J. Scott
"Operation of small pumping stations"	Grant M. Olewiler
"Industrial wastes in the pollution control program"	Milton P. Adams
"Principles and factors influencing vacuum filtration of sludge"	A. L. Genter
Federation Luncheon Guest Speaker	Hon. Walter D. Binger Commissioner of Borough Works Borough of Manhattan

Symposium:

Control and operation of sewage treatment units

Leader: C. C. Larson

a. Standards of successful operation .... Charles Gilman Hyde
b. Biological filters .... M. W. Tatlock
c. Sludge digestion .... Guy E. Griffin
d. Screening, handling, and disposal .... Wellington Donaldson
e. Cold weather operation .... Albert E. Berry
f. Records .... Roy S. Lanphear

Banquet—Entertainment—Dancing

Saturday, October 11th

Breakfast—Operators, engineers, manufacturers, everybody

Operators' Turn-Table

Leaders: LeRoy W. Van Kleeck and B. A. Poole

Business session of the Federation of Sewage Works Associations

Buffet Luncheon—Get together of Regional Associations and veteran operators

Final view of exhibits

Inspection trip—Bowery Bay Treatment Plant

Special features of the Convention include:

The Stag Smoker Thursday night; Dinner-Dance and Entertainment Friday night; Luncheon Friday noon, with Commissioner Walter D. Binger as Guest Speaker; Luncheon Saturday noon, followed by recognition of veteran operators of 25 or more years' experience; Inspection of Bowery Bay Treatment Works of the City of New York.

Ladies' Entertainment will include a Luncheon Friday noon at Town Hall, followed by a tour of Radio City; a Tea and Fashion Show Friday afternoon; and of course the Banquet, Dance and Entertainment Friday night.

Operators' Own Session will feature Saturday morning's program, following the Breakfast, for which a reduced rate of 75 cents has been secured.

Registration Rates, Costs of Special Dinners, Hotel Rates, etc., have been announced in the circular "Here's Why" sent to each member by Secretary Wisely. If you haven't made a reservation at The Pennsylvania, do so immediately.

Exhibitors

All those who attended the Chicago Convention last year will recall the outstanding value and interest of the exhibits. The exhibits at New York will be even more interesting, according to J. Herman Smith, *Chairman* of the Exhibit Committee, who released the following list as of August 25th:

Aluminum Company of America
American Brass Co.
American Cast Iron Pipe Co.
American City Magazine
American Rolling Mill Co.
Carson-Cadillac Co.
Carter, Ralph B. Co.
Chain Belt Co.
Chapman Valve Mfg. Co.
Chicago Pump Co.
Crane Company
Dorr Company
Electro-Rust-Proofing Co.
Engineering News-Record
Fairbanks-Morse Co.
Flexible Sewer Rod Equipment Co.
General Electric Co.
Homelite Corp.
International Filter Co.
Johns-Manville
Lakeside Engineering Corp.
Limestone Products Corp. of America
Link-Belt Co.
Mathieson Alkali Works
Monsanto Chemical Co.
Nichols Eng. & Research Corp.
Pacific Flush Tank Co.
Pittsburgh Equitable Meter Co.
Merco-Nordstrom Valve Co.
Public Works Magazine
Royer Foundry & Machine Co.
Sewage Works Engineering
Tennessee Corp.
U. S. Pipe & Foundry Co.
Vapor Recovery Systems
Wailes Dove-Hermiston Corp.
Wallace & Tiernan Co.
Water Works & Sewerage
Wood, R. D. Co.
Yeomans Bros. Co.

Most of these exhibitors advertise regularly in the Sewage Works Journal, and their featured products are described in the special section "Advertisers' Contributions." Please read the articles in this Section and you will be well prepared to look for the things that interest you most, when you get to the Convention.

Committees

Convention Committees are as follows:

Convention Management

Arthur Bedell, *Chairman*
Charles A. Emerson
Wm. Orchard
L. L. Luther
Clinton Inglee
J. Herman Smith

Program

F. W. Gilcreas, *Chairman*
Rolf Eliassen
James L. Ferebee
F. W. Mohlman
F. C. Roberts
W. W. Towne
LeRoy Van Kleeck
Charles Velzy

Local Host

Richard Gould, *Chairman*
James L. Barron
John Brooks
Rodney Cook
Gail P. Edwards
Weston Gavett
Seth Hess
Frank W. Jones
W. H. Larkin
L. L. Luther
Clarence MacCallum
R. M. McLaughlin
George Moore
H. E. Moses
Willem Rudolfs
Walter Shea
Richard Smith
George Symons
Wm. Sylvester
Robert Wheeler

Publicity and Attendance

Morris Cohn, *Chairman*
Anthony Anable
E. J. Cleary
Linn Enslow
T. R. Kendall
A. M. Rawn
A. J. Wagner

Registration

Rolf Eliassen, *In Charge*

Inspection Trip

W. Donaldson, *Chairman*
Francis Laverty
William O'Leary
Wm. Raisch

Ladies' Entertainment

Mesdames:

Karl Mann, *Chairman*
Arthur Bedell
Morris Cohn
Wellington Donaldson
Charles Emerson
Linn Enslow
F. W. Gilcreas
Richard Gould
L. L. Luther
F. W. Mohlman
Wm. Orchard
H. H. Wagenhals
W. H. Wisely

Proceedings of Local Associations

MICHIGAN SEWAGE WORKS ASSOCIATION

Sixteenth Annual Meeting, Michigan State College, East Lansing, Michigan June 18–20, 1941

The sixteenth annual conference of the Michigan Sewage Works Association was held at Michigan State College, East Lansing, Michigan on June 18, 19 and 20, 1941. Each year the conference follows the short course school. The attendance at the two and one-half day school totalled 59 and at the conference 92.

President A. B. Cameron presided at the sessions the first two days and much credit is due him for the way discussion of papers from the floor was brought out by the attending members. There was perhaps greater participation by the members this year than at any conference of recent years. The following papers were presented:

"Aero-Chlorination: A Method for the Removal of Grease" by Harry A. Faber, Research Chemist, The Chlorine Institute; "Operating Results and Experiences, Birmingham, Michigan, Sewage Treatment Works" by Stanley J. Mogelnicki, Superintendent; "Filtration of Sewage Sludge" by C. T. Mudgett, Superintendent of Muskegon Michigan Sewage Treatment Works and George Wyllie, Superintendent of Lansing Michigan Sewage Treatment Works; "Financing Sewage Treatment Facilities by Revenue Bonds" by Herbert A. Olson, Director, Michigan Municipal League; "Testing of Chlorine in Sewage" by Dr. W. L. Mallmann, Associate Professor of Bacteriology, Michigan State College; "Odor Control at Sewage Treatment Works" by W. H. Wisely, Executive Secretary, Federation of Sewage Works Associations; "Early Operating Experiences at Detroit Sewage Treatment Works" by W. M. Wallace, Superintendent and Arthur B. Morrill, Engineer of Sewage Treatment, Detroit, Michigan; "The Writing of Paint Specifications for Sewage Works" by W. T. McClenahan, Senior Civil Engineer, Sanitary District of Chicago; "Sewage Treatment Plant Operators and the Law" by Harry W. Jackson, Assistant Attorney General; "Sell your Plant" by N. G. Damoose, Engineer Manager, Sewage Treatment Works, Battle Creek, Michigan; "Safety Appliances for Sewage Treatment Works" by F. R. Davis, President, Davis Emergency Equipment Co., Inc., New York, N. Y.

At the annual business meeting on June 19 the following officers were elected for the year 1941–42:

President: Arthur B. Morrill, Detroit.
Vice-President: L. R. Jennings, Owosso.
Director: R. A. Greene, Jackson.
Continuing Director: J. F. Leemaster.
Secretary-Treasurer: Robert J. Smith, Lansing.

Willard F. Shephard, the retiring Secretary-Treasurer, was elected an Honorary Lifetime Director by unanimous vote. Mr. Shephard has been the Secretary-Treasurer and one of the mainstays of the Michigan Sewage Works Association since it was organized some sixteen years ago. As an expression of their appreciation for what he has done for the Association in his many years of service, the operators presented Mr. Shephard with a Seth Thomas Banjo Clock.

N. G. Damoose was reappointed to the Board of Control by President Morrill. Mr. Damoose reported on the winter meeting of the Board of Control of the Federation which he attended in New York. Much of the discussion centered around this report with particular reference to the question of affiliate members and the new Constitution. A resolution was passed to the effect that this Association is interested in an affiliate grade of membership, with those assigned to this grade to receive all publications of the *Sewage Works Journal* at the present subscription price of $1.50 per year.

Robert J. Smith, *Secretary*

NEW YORK STATE SEWAGE WORKS ASSOCIATION

Annual Spring Meeting, Niagara Falls, N. Y., June 19–21, 1941.

The annual spring meeting of the New York State Sewage Works Association was held in Niagara Falls on June 19–21, 1941, with headquarters at the Hotel Niagara. Over 175 members and guests were registered.

The general arrangements and program were arranged by the Western Section of the Association and the technical program was of particular interest to operators.

Following a brief business meeting, Thursday afternoon, Walter Smith of the town of Tonawanda opened the program with a paper on "Corrosion of Metals by Electrolysis." The paper was illustrated by charts and a demonstration. This was followed by a paper on the "Disinfection of Sewage by Chlorination," by Dr. G. E. Symons, Chief Chemist, and R. W. Simpson, Associate Sanitary Chemist, Buffalo Sewer Authority. Edward J. Smith, Superintendent of the Niagara Falls plant presented a paper on "Undewatered Sludge Incineration" based on experience at Niagara Falls.

Thursday evening was devoted to a social gathering and enjoyment of the scenic attractions of Niagara Falls including the illumination of the Falls.

On Friday morning the technical program continued with a symposium on "High Capacity Filtration of Sewage" which included papers by Frank Bachmann on the "Bio-Filter Process," by H. W. Gillard on "Accelo Filter System," and by J. A. Montgomery on "Aero Filter Process," which provoked considerable discussion. This was followed by a paper by Mr. John Slough, Superintendent of the Sewage Treatment Plant at Wellsville on the "Daily Care of the Sewage Plant." Owing to lack of time Harry A. Faber's paper on "Chlorine Problems" was postponed until the Saturday morning session where it aroused considerable valuable discussion.

One of the features of the meeting was the gadget competition and some twelve gadgets were displayed. First award went to J. A. Fitzgerald of Hudson Falls for his depth sampler, second award to E. A. Marshall and E. A. Larsen of Geneva for a sludge grinder and third award to Bruce Strong of Olean for a lawn sprinkler.

At the noon luncheon Friday Mayor Ernest W. Mirrington, Jr., welcomed the group following which the presentation of the operators' annual award, in accordance with the schedule set up by the Rating Committee, was made by C. C. Agar, Chairman of the Committee. It was noted that due to the excellence of two reports two awards in the form of silver loving cups were made, one to W. D. Denise, Chief Operator for the Greece Sewer District, and the other jointly to James T. Lynch and H. E. Milliken, operators of the Auburn Sewage Treatment Works. The principal speaker at the luncheon was Francis D. Bowman, Advertising Manager of the Carborundum Company, who spoke on the "Lore and Legends of the Iroquois Indians."

Friday afternoon was devoted to an inspection of the Niagara Falls sewage treatment plant and in the evening all enjoyed the usual informal banquet, entertainment and dancing.

On Saturday morning following the usual sunrise breakfast and Superintendents' Question Box the meeting adjourned to inspect the sewage treatment plants of the town of Tonawanda, city of Tonawanda and city of Lockport, New York.

Thursday afternoon and Friday afternoon some thirty ladies enjoyed the hospitality of the Chamber of Commerce in a trip to the Shredded Wheat Company plant and a luncheon and trip around the Falls including the Canadian side.

The next meeting of the Association will be held in New York City on October 9, 10 and 11, 1941, at which the New York Association will be host to the Federation of Sewage Works Associations at its second annual convention.

A. S. Bedell, *Secretary*

CONFERENCE OF WISCONSIN SEWERAGE WORKS OPERATORS

Sheboygan, Wisconsin, May 26–28, 1941

The 1941 Conference of Wisconsin Sewerage Works Operators was held at Sheboygan, Wisconsin, May 26, 27, 28, 1941.

The program of the Conference shows the type of papers and talks that were given. The subjects were discussed by all of those interested, and valuable information was brought out and absorbed by all.

It will be noted that the program subjects are of such nature whereby all subjects could be understood by all those in attendance. The prime object of this type of program was to get away from distinctly theoretical and research matter and make the program for the operators themselves. This was accomplished, we believe, and the men went away from the Conference with a better understanding of sewage treatment.

A resolution was drawn and sent to the state legislative body then in session, approving the pending act of licensing sewage and water treatment plant operators. The act was vetoed, so further work will have to be done on the bill to be presented again at a future session.

The new officers are:

President: Geo. Martin, Green Bay.
First Vice President: J. C. Mackin, Madison.
Second Vice President: R. W. Frazier, Oshkosh.
Secretary-Treasurer: W. J. Goluecke, Green Bay.

W. H. Wisely, executive secretary of the Federated Sewage Works Associations, was the principal speaker of the Conference.

Attendance at the Conference consisted of 73. 10 non-members and 63 members.

Monday—May 26, 1941

8:00–10:00 A.M.	Registration for New Operators (Grand Hotel).
10:00–10:30 A.M.	Sewage Treatment Terms and Definitions.
10:30–11:20 A.M.	Laboratory Up-Keep.
11:00–12:00 A.M.	Sample Collection.
12:00– 1:30 P.M.	Luncheon.
1:30– 4:00 P.M.	Laboratory Demonstrations at Sheboygan Sewage Treatment Plant (pH, Settleable Solids, Suspended Solids, D.O., B.O.D., Residual Chlorine).
4:00– 5:00 P.M.	Sewage Treatment Plant Records.
	(Monday's entire program conducted by the Wisconsin State Board of Health staff members.)

Tuesday—May 27, 1941

8:00–10:00 A.M.	Registration (Grand Hotel).
10:00–10:15 A.M.	Electrolysis in Sewage Treatment Plants by Oscar Ward, Marshfield.
10:15–10:30 A.M.	Open Discussion.
10:30–10:45 A.M.	Heating and Ventilating by George Martin, Green Bay.
10:45–11:00 A.M.	Standardization of Gas Engine Reports by R. W. Frazier, Oshkosh.
11:00–11:10 A.M.	Maintenance of Chlorinators by W. J. VandenNoven, Green Bay.
11:10–11:20 A.M.	Maintenance of Chlorinators by Clem Coenen, De Pere.
11:20–11:30 A.M.	Use of Chlorine by H. E. Wirth, Wisconsin State Board of Health.
11:30–12:00 A.M.	Sewage Sludge as a Fertilizer—Open Discussion.
12:00– 1:30 P.M.	Luncheon.
1:30– 2:00 P.M.	Digester Explosion by Jake Klein, Sheboygan.
2:00– 2:30 P.M.	Sewerage Works Insurance by Gerry Pauly, Sheboygan Board of Fire and Casualty Underwriters.
2:30– 3:00 P.M.	Open Discussion.
3:00– 3:30 P.M.	Vacuum Filtration by Jess Holderby, Neenah-Menasha.
3:30– 3:45 P.M.	Open Discussion.
3:45– 4:15 P.M.	Sewage Sludge Digestion by W. H. Wisley, Urbana, Illinois.
4:15– 5:00 P.M.	Kinks in Operation—Open Discussion.
6:00– 7:30 P.M.	Banquet.
7:30——— P.M.	Business Meeting.

Wednesday—May 28, 1941

8:00– 8:20 A.M.	Trickling Filters by John Mackin, Madison.
8:20– 8:30 A.M.	Open Discussion.
8:30– 9:15 A.M.	Biofiltration-and-Garbage and Sewage Sludge Disposal by Digestion by D. C. Reybold, Dorr Co., Inc.
9:15– 9:30 A.M.	Open Discussion.
9:30–10:00 A.M.	Activated Sludge by N. E. Hartung, Richland Center.
10:00–10:30 A.M.	Open Discussion.
10:30–11:00 A.M.	Role Sewage Treatment Plays in Defense by Jerry Donohue, Jerry Donohue Engineering Company.
11:00–11:20 A.M.	Starting a New Separate Sludge Digestion Plant by W. R. Reardon, Manitowoc.
11:20–11:40 A.M.	Starting a New Activated Sludge Plant by Arthur Tomek, Two Rivers.
11:40–12:00 A.M.	Public Relations—Open Discussion.
12:00– 1:15 P.M.	Luncheon.
1:15——— P.M.	Inspection of Sheboygan Sewage Treatment Plant.

R. W. Frazier, *Second Vice-President*

DISTRICT SEWAGE TREATMENT CONFERENCES HELD IN IOWA, 1941

District conferences for local officials and sewage plant operators are becoming increasingly popular in Iowa. These conferences are sponsored jointly by the Iowa State Department of Health and the various cities and towns. The purpose of these conferences has been to afford an opportunity for local officials and plant operators to get together and discuss their common problems of sewage treatment. The programs have in the most part centered around the management and operation phases of sewage treatment plants.

On March 18 a district conference was held at Cresco, Iowa, with an attendance of 32 persons representing 14 towns. Mr. McAllister, Mr. Altfellisch, Mr. Hebig, and Mr. Coonradt were discussion leaders, with everyone participating in open discussion. The group was enthusiastic about the district type of conference and expressed a desire to hold a similar conference every six months.

On March 19 a district conference was held at Cedar Rapids with an attendance of 48 persons representing 21 towns. Mr. J. C. McIntyre, superintendent of the Cedar Rapids plant, very ably presided at the conference. The desire was expressed to continue these conferences twice yearly to be held at various cities and towns throughout the district.

On March 20 a joint conference was held at Waterloo and Cedar Falls. Sixty persons representing 21 towns were present, which included several councilmen and six mayors. C. T. Wilson, superintendent, Waterloo treatment plant, and Mr. Clark H. Streeter, superintendent, Cedar Falls treatment plant, presided. Lunch was served at the Waterloo sewage treatment plant and a buffet supper served at the Cedar Falls Chamber of Commerce.

On June 25 a district conference was held at Webster City with an attendance of sixty persons and 25 towns represented. J. A. Sampson, district public health engineer, presided over the morning session which included short talks by city manager C. C. McCarthy, C. H. Currie, president, Currie Engineering Co., B. O. Osborn, president of the Chamber of Commerce, and Leo Holtkamp, operator of the Webster City plant.

At noon the group enjoyed a buffet luncheon at the plant.

C. D. Mullinex, assistant engineer of the State Department of Health, gave a review of sewage treatment in Iowa.

G. C. Ahrens, superintendent of the sewage plant at Marshalltown, led a round-table discussion assisted by H. H. Anderson of Humboldt, Bob Davis of Nevada, and Dan McCaully of Sac City. Later the group drove to Fort Dodge where that plant was inspected and described by T. R. Lovell, engineer-in-charge.

J. A. Sampson, *Public Health Engineer,*
Iowa State Dept. of Health

CENTRAL STATES SEWAGE WORKS ASSOCIATION

Notice of Fourteenth Annual Meeting

The fourteenth annual meeting of the Central States Sewage Works Association will be held at the Anthony Hotel, Fort Wayne, Indiana, on October 6 and 7, just prior to the second annual convention of the Federation of Sewage Works Associations.

E. J. Beatty, *Secretary*

Reviews and Abstracts

CALCO'S NEW WASTE TREATMENT PLANT

By C. E. Mensing, R. L. Cassell, C. H. Bean, H. C. Spencer and V. L. King

Chemical and Metallurgical Engineering, **48**, 84–88 (March, 1941)

Pilot plant studies of the wastes from the Bound Brook, New Jersey, plant of the Calco Chemical Division of the American Cyanamid Company, which produces approximately 900 different wastes, resulted in the development of basic treatment methods as follows: (*a*) Special treatment at source for all troublesome effluents, (*b*) settling all solids and skimming all oils, (*c*) destruction of all sanitary sewage by taking advantage of the strongly acid nature of most of the effluents, (*d*) thorough compositing (24-hour compositing is believed to be enough for mutual destruction), (*e*) neutralization of residual acidity, (*f*) final settling, bleaching and aeration, (*g*) diffusion into full flow of Raritan River. The pilot plant cost approximately $20,000. A full scale treatment plant costing $325,000.00 was constructed during the period 1938–1940.

The collecting system consists of two 36 in. trunk sewers, underground surge basins and interceptors, all of which drain to a collecting sump. The collecting sump is approximately 125 ft. × 125 ft. in plan and is 18 ft. deep, and holds approximately 350,000 gallons. The pump suction lines are located at the end of this basin. The collecting system is provided with a relief weir which by-passes the wastes to the river in case of a pump station shut-down. As a result of a number of tests on materials of construction for the pumps and valves, bronze was chosen. The pump suction lines are of cast iron lined with an acid resisting paint coating. The four pumps discharge into a lead-lined pipe which empties into a 36 in. wood stave pipe outside the pumping station. This pipeline carrying the untreated wastes discharges against a wooden baffle into the compositing basin of 10 M.G. capacity and 5.5 acres surface. In this basin a number of chemical reactions occur between the various types of waste. This is considered a vital step in the process since the compositing provides a relatively uniform basin effluent. Residual acidity in the uniform effluent from the compositing basin is neutralized by a calcium carbonate slurry, which is introduced uniformly across the basin effluent channel by an overflowing, notched, distribution trough. The waste and slurry then flow into a neutralizing chamber where the mixture is agitated by two propellers. From the neutralizing chamber the waste flows to a 23 acre 60 M.G. settling lagoon, having a detention time of 5 to 6 days at normal flow.

The calcium carbonate slurry is obtained as a waste from the nearby Johns-Manville Corporation. Based on pilot plant batches from 7.5 to 22.5 tons per day (average 14 tons per day) of dry calcium carbonate are necessary to neutralize 15 M.G.D. of plant waste. To transport and prepare the slurry for use requires a slurry tank and pump station at Johns-Manville, a pipe line to the Calco plant and a slurry tank, classifier, slurry thickener, and 10 M.G. slurry storage basin at the Calco plant. If the Johns-Manville production at any time is insufficient to supply the calcium carbonate necessary for neutralization settled calcium carbonate will be hydraulically mined from the storage basin and pumped to the slurry tank. The rate of addition of the concentrated slurry from the thickener to the distribution trough is controlled by an air operated gate valve which throttles a gun rubber hose carrying the slurry. A Micromax pneumatic pH controller provides the control on the air operated valve. The glass electrodes to measure the pH of the neutralized waste are mounted in a special flow chamber into which neutralized effluent is pumped continuously.

Neutralized effluent from the 60 M.G. final settling tank flows into Cuckolds Brook near the treatment plant and the combined flow goes through a canal approximately 6,000 feet into an overflow, diffusion dam in the Raritan River. The diffusion dam is a reinforced concrete structure which encloses a 36 in. tile pipe. The central portion of the dam is 123 ft. long and in this section the tile pipe has forty one 8 in. outlets spaced at 3 ft. centers on the downstream side of the dam. The effluent thus discharges into the full flow of the river as it pours over the dam.

A special waste disposal department maintains a system of constant inspection of the individual process effluents at the various sources to prevent undue pollution reaching the treatment plant. The plant operator has been licensed by the New Jersey Department of Health.

Four illustration and one flow sheet showing plant in plan and elevation are included.

Paul D. Haney

SULFURIC ACID FROM REFINERY SLUDGE

Chemical and Metallurgical Engineering, 48, 144–145 (May, 1941)

A pictured flow sheet showing the steps in the process of sulfuric acid recovery from oil refinery sludge. The acid sludge is heated to about 550° F. at which temperature it decomposes into sulfur dioxide, solid coke, water vapor and a small quantity of hydrocarbon vapor. The sulfur dioxide can be processed by the contact method to clean sulfuric acid.

Paul D. Haney

THE BIOLOGY OF THE MACRO–FAUNA OF A HIGH–RATE DOUBLE FILTRATION PLANT AT HUDDERSFIELD

By T. B. Reynoldson

The Surveyor, 99, 237–240 (April 4, 1941)

The author describes 13 months' studies of biological growths in an experimental high-rate trickling filter plant at the Huddersfield Corporation sewage works. The sewage treated is rather strong and is composed of two parts domestic sewage, one part textile waste and one part chemical trade waste. The primary filter was 18 ft. in diameter and 7 ft. deep with clinker 2–4 in. in size throughout. The secondary filter was also 18 ft. in diameter, but 6 ft. deep with clinker size varying with the depth as follows: top 18 in., 4–6 in.: middle 36 in., 1–½–3 in.: bottom 18 in. 3–6 in. Both filters were dosed with 4-arm rotary distributors. The distributor for the secondary filter was equipped with spray nozzles. Spray nozzles were not considered necessary for the primary filter unit, the force of the sewage impinging on the media giving an efficient spray. The rate of dosage on the primary filter was 9 to 10 M.G.A.D. and on the secondary filter 2 to 3 million gallons. The speed of rotation of the primary distributor was 9 to 10 R.P.M. The secondary distributor revolved " slowly " at much less speed.

The experiments indicated that high rates of flow tend to restrict the variation of fauna. Thus the secondary filter showed 10 breeding species and the primary filter only two. In the primary filter *Psychoda* flies and larvae were more numerous in the lower depths: in the secondary filter fauna were more numerous at the surface and in the upper layers. High rates also reduce the total abundance of the fauna. There is a decided inverse correlation between the extent of ponding and the number of *Psychoda*. There is a constant struggle between accumulation of growth and sludge and its removal by larvae helped by the flushing action of the sewage. If sludge accumulation predominates ponding results. The scouring activity of the larvae is the main agency in keeping beds open and aerated.

The author does not attribute clean beds to high rates of flow and states that the very closely adhering fungal and bacterial slimes and sludge accumulations are not likely to be washed out by any flushing action of the sewage, which after all, only trickles downwards at a faster rate.

K. V. Hill

ROUND TABLE DISCUSSION OF OPERATING PROBLEMS OF SEWAGE TREATMENT

Journal North Carolina Section, A. W. W. A., 16, 118 (1941)

Coagulants as Used in Industrial and Domestic Waste Treatment. By Francis K. Burr. The general application of chemicals in sewage treatment was discussed. Mention was made of the use of alum and acid in reducing the B.O.D. load on the activated sludge units of sewage containing a high content of textile waste at Greensboro. At Somerville, ferric chloride was used along with alum to produce an easily settleable floc. At Atlanta copperas is used to increase the effectiveness of trickling filters. Presumably the iron oxide coating on the stone catalyzes oxygen transfer. Other uses of alum or iron are mentioned in a general manner.

The discussion of this paper centered around problems involving color removal from the effluent and the effectiveness of dilution of sewage containing a high concentration of textile wastes with river water. No definite conclusion was reached regarding effective methods of removing color, although it was agreed that alum was helpful. The general opinion on the use of dilution water was that it could be used advantageously in many plants.

Digestion of Mixed Chemically Precipitated Primary Sludge and Secondary Sludge from Trickling Filters. By H. D. Fesperman. Successful digestion of a mixed sludge consisting of primary sludge, chemical sludge and secondary sludge from tricking filters was accomplished at Albemarle by operating in a semi-batch process method. The plant had two digesters of sufficient capacity to enable the operator to pump all his sludge into one tank for a period of ten days and then rest the tank for ten days while sludge was being pumped to the other tank. At the end of twenty days either the supernatant was withdrawn or the sludge, if ripe, was drawn to the drying beds to allow a second ten day pumping cycle.

It is claimed that the digestion period is speeded up and that gas production is more constant by this method of operating the digestion tanks. Tank temperatures (100° F.) are more easily controlled because the disturbance due to many pumping cycles per day is eliminated.

Drying of Sludge on Heated Sludge Beds. By L. A. Lubow. Heating coils laid parallel on five inch centers in some of the covered drying beds at Durham enabled the operator to greatly increase the drying capacity of these units. Cooling water from the gas engines was circulated through these coils to supply the heat. Data collected over a period of years which is shown in the table indicates the effectiveness of this system of drying:

Beds	Dry Solids Removed Pounds per Bed (2500 sq. ft.) per Year	Per Cent Increase	
		Units	Over All
Uncovered	64,926		
Covered	86,773	33.6	
Covered-heated	106,867	23.1	64.6

The discussion brought out that heating the sludge on the beds has a tendency to permit digestion to continue thus generating gas which tends to float the solids and permit the water to drain off. Heat also decreases the viscosity of the mixture, causing it to drain more quickly.

From the economic point of view it was disclosed that the slight increase in the cost of the beds (10 per cent) was very many times compensated for by the increase in drying capacity.

Dewatering Activated Sludge. By J. H. Henderlite. The paper stated very briefly the general practice in dewatering activated sludge. The discussion centered around the binding and cleaning of filter cloths and the corrosiveness of ferric chloride. Experience with the use of sodium phosphate and muriatic acid in cleaning cloths was mentioned but no conclusions reached. The corrosive effect of ferric chloride on the life of the cloth and metal parts of the filter was mentioned.

E. Hurwitz

A STUDY OF THE METHODS OF MEASURING GERMICIDAL CHLORINE WITH REFERENCE TO THE OXIDATION–REDUCTION POTENTIAL, STARCH IODIDE TITRATION AND ORTHOTOLIDINE TITRATION

By W. L. Mallman and William B. Ardrey

Engineering Experiment Station *Bulletin,* Vol. 16, No. 3, Michigan Engineering Experiment Station

A comparison of the oxidation-reduction potential, starch iodide titration and ortho-tolidine titration as a means of measuring the germicidal action of chlorine was made in these studies. A bright platinum electrode was used for measuring the oxidation-reduction potential. Observations were made separately on solutions containing colloidal organic matter (agar) and soluble organic matter (peptone) which had been stabilized by permitting the chlorine (NaOCl) and organic matter to reach equilibrium by aging for 24 hours. Observations were also made on unstabilized solutions.

Available chlorine up to 4 p.p.m. was added to the various solutions and data taken of the voltage, starch iodide titration, the ortho-tolidine titration and bacterial reductions. The pH of the solutions studied was standardized at 5, 7 and 9.

The studies indicated that there was a distinct relationship between the oxidation reduction potential of chlorine solution containing from 0 to 1.5 p.p.m. of titratable chlorine and the immediate germicidal activity of such solutions. There was a gradual increase in oxidation-reduction potential of titratable chlorine up to 0.9 to 1.1 p.p.m. chlorine followed by a sharp rise with increasing chlorine concentration. Simultaneously an increase in germicidal activity accompanied this rise. The same relationship existed at all pH values.

When increasing concentrations of chlorine were added to solutions containing 0.1 per cent agar and allowed to become stabilized, the titratable chlorine first increased, then dropped to zero and finally increased again. The oxidation-reduction potential and bacterial reductions followed this same trend. However the values obtained by ortho-tolodine and starch iodide titrations were too high before the disappearance of chlorine and too low after. The oxidation-reduction potential in each case gave a true evaluation of the germicidal activity.

When increasing concentrations of chlorine were added to peptone and allowed to become stabilized, a poisoning effect on the oxidation-reduction potential was noted which tended to hold the chlorine in the non-germicidal range. Further increase in chlorine overcame this effect; the voltage rose sharply and was accompanied by a marked increase in bacterial reductions. No correlation was found between the starch iodide and ortho-tolidine titrations and bacterial reductions.

On adding increasing amounts of chlorine to unstabilized agar and peptone solutions, the oxidation-reduction potential again gave a better indication of germicidal activity than did ortho-tolidine or starch iodide. The same results were obtained on chlorinated sewage studies.

Conclusions from these studies are that the present methods of measuring available or germicidal chlorine by means of starch iodide or ortho-tolidine titration are of dubious value, especially in the presence of organic matter. On the other hand oxidation-reduction determinations give a true indication of the germicidal activity of different concentrations of chlorine both in the presence and absence of organic matter.

E. Hurwitz

TREATMENT OF TANNERY WASTES WITH FLUE GAS AND LIME

BY H. B. RIFFENBURG AND W. W. ALLISON

Ind. and Eng. Chemistry, 33, 801 (June, 1941)

Sewage from a medium sized tannery (300 hides per day) was studied in order to reduce the pollutional load on the stream receiving the discharge. Analyses of the wastes from the different tanning processes were made and are shown in the table:

Waste	Discharge G.P.D.	Sp.G.	pH	Total Solids P.P.M.	Nitrogen P.P.M.	Hide Substance P.P.M.	B.O.D. P.P.M.	Oxygen Consumed P.P.M.
Soaks	9,000	1.004	7.45	8,352	88.6	496	600	900
Limes	3,300	1.002	11.5	36,488	28.6	160	1,700	1,750
Lime Wash	4,000	1.004	8.1	8,944	225.	1,257	535	900
Unhairing and Fleshing	3,860	1.000	10.5	3,860	166.	929	3,000	1,050
Deliming and Bating	600	1.001	6.7	5,644	325.	1,818	1,650	900
Tanning	18,000	1.013	5.4	33,496	—	—	13,600	22,000
Soda Pool	21,000	1.015	9.3	21,244	43.	204	3,750	15,900
First Rinse	—	1.005	7.9	12,820	—	—	2,750	9,125
Acid Pool	1,800	1.015	1.8	13,460	25.7	155	2,000	5,425

Experiments with various chemicals indicated that satisfactory results can be had by the use of flue gas and lime.

Spent liquors from the lime soaks, bating, tanning and bleaching processes are combined and mixed in a storage tank large enough to hold the accumulation from 24 to 36 hours operation. The mixture is saturated with flue gas until the pH has been lowered to 6.7–6.4. Lime water is then added until the reaction is alkaline to phenolphthalein and the mixture allowed to settle. Crystals of calcium carbonate settle out and carry down with them large amounts of colloidal and suspended matter. The supernatant is drawn off and the treatment repeated on it. The supernatant from the second treatment is sufficiently reduced in putrescible matter and color to permit discharge into the stream. Sludge is dewatered on cinder beds.

A reduction in B.O.D. from 13,400 p.p.m. to 3,000 p.p.m. is claimed for the first stage. This is further reduced to 1,140 p.p.m. by the second stage. Color removal was very effective.

No data are given of the amounts of lime used in addition to that discharged with the waste nor of the volume and CO_2 concentration of flue gas. The total amount of lime found in the sludge is reported as 37.6 per cent CaO dry weight.

E. HURWITZ

SLUDGE DISPOSAL DOMINATES PLANT DESIGN

BY HARRY A. HALL

Engineering News-Record, 126, 748 (May 8, 1941)

The Washington Suburban Sanitary Commission has constructed a primary sewage treatment plant on the banks of the Anacostia River, adjacent to Washington, D. C. The plant is designed for 7.5 m.g.d. and provides for primary sedimentation followed by chlorination of the effluent. The significant features of the plant are the grease flotation and sludge elutriation systems employed.

Two-stage elutriation of digested sludge, with or without supernatant liquor, is provided. Final effluent or ground water will be used to wash the sludge in a counter-current system. Two to three volumes of wash waste will be used for each volume of sludge. Based upon operating 8 hours daily and 5 days per week, each elutriation tank will provide a surface area of about 120 sq. ft. per ton of dry digested solids. When elutriating, the design flows of digested sludge, plus supernatant liquor, with 3 : 1 wash water, the detention period in each elutriation tank will be about 1.7 hours. Hence, when the supernatant liquor is not elutriated, the detention period with 3 : 1 wash water will be about 5 hours. Two small rectangular, baffled mixing tanks are provided for mixing sludge and wash water. Two 26 ft. diameter settling tanks with the picket fence thickening blades are provided for concentrating the sludge after elutriation in each stage.

Each of the two rectangular primary settling tanks is preceded by a 3-pass baffled tank in which air can be bubbled through the sewage. The detention period in these aeration tanks averages from 4 to 8 minutes. The quantity of air required for grease flotation will average about 0.1 cu. ft. per gallon of sewage. To increase the efficiency of flotation, provision is made for the introduction of chlorine solution at a point where the sewage enters the tank. The chlorine dosage may be varied from 1 to 3 p.p.m.

Rolf Eliassen

FOURTEENTH ANNUAL REPORT, OHIO CONFERENCE ON SEWAGE TREATMENT

October 1–2, 1940

Recent Trends of Municipal Sewage Treatment in Ohio, by W. H. Knox, pp. 14–23. There are 186 sewage treatment plants in 54 cities and 125 villages in Ohio. Since 1934 entirely new plants have been built at 28 cities and 79 villages and improvements or additions have been made at 7 cities and 10 villages. The paper continues with brief discussions on sewage pumping, screens, grease separators, grit chambers, primary and secondary settling tanks, chemical treatment, trickling filters, sand filters, activated sludge, secondary fine-grained filters, sludge digestion and disposal, gas engines and chlorination. Three tables of plant statistics are given.

Operation of the Waste Treatment Plant of the Gulf Brewing Company, Houston, Texas, by S. L. Tolman, pp. 24–34. Preliminary pilot plant tests for the treatment of the brewery wastes were described in *This Journal,* **11**, 295–307 (March, 1939). The actual plant consists of a pumping station, two settling tanks equipped for mechanical sludge removal, dosing siphons, two trickling filters, final settling tank, sludge digester, sludge drying beds, and laboratory building. The plant was designed for flexibility of operation. Plant operating data for the year 1939 are presented in three tables which give monthly average values of flow, detention time, suspended solids and 5-day B.O.D. The overall efficiency of the plant from influent to final effluent is 83.7 per cent removal of suspended solids and 96.5 per cent removal of 5-day B.O.D.

Data regarding the sanitary condition of the receiving body of water above and below the treatment plant are given for 1939.

The author summarizes the paper with the following conclusions:

(1) Strong brewery wastes can be satisfactorily oxidized by series trickling filters.
(2) With rates of application of 10 lb. of 24-hour B.O.D. per 100 cu. ft. of stone, 95 per cent removal of 24-hour B.O.D. may be expected.
(3) Operation of filters causes no unusual problems.
(4) Filter flies can be controlled by applying 40 p.p.m. of chlorine to the primary filter influent.
(5) Brewery sludge can be satisfactorily digested.

Two photographs, one flow diagram, three tables of operating data.

Vacuum Filtration and Incineration at Cleveland, Ohio, by G. E. Flowers and W. E. Gerdel, pp. 35–47. The City of Cleveland is served by three sewage treatment plants, the Easterly, Westerly and Southerly. The Southerly plant is equipped with eight Filtration Engineers, Inc., filters of the string discharge type, each of which has a surface area of 320 sq. ft. The Westerly plant employs four 165 sq. ft. Oliver type filters. Sludge and skimmings from the Easterly plant are pumped 13 miles to the Southerly plant for final disposal.

Considerable experimenting on the type of filter cloth best suited to Cleveland conditions has been carried out. Cotton cloths have proven the most satisfactory.

Various methods of cleaning the screen filter cloth supports were tried at the Westerly plant but the best method was found to be cleaning in place with muriatic acid. This is accomplished with the aid of a rubberized cloth inserted between the filter pan sludge agitator and the filter drum. This cloth acts as an apron to provide muriatic acid solution of such a depth that the lowest section of the drum is submerged. Each section is submerged in turn. The rubberized cloth is prepared by coating filter cloth with latex. One filter requires about 4 hr. time and 30–40 gal. of muriatic acid for cleaning. The filters at the Southerly plant are similarly cleaned with acid except that the acid is sprinkled on the top section of the drum. This is repeated until all sections have been treated. The process takes about eight hours and requires 40 gal. of acid.

Other items discussed include points of chemical application, effect of incineration on chemical dose, effects of chemical application, relation between solids content and yield and benefits from increased solids content of sludge. The latter include (1) less volume of sludge and vacuum filtrate to handle, (2) savings in conditioning chemicals, (3) greater filter yields, (4) increased life of filter cloth due to decreased amounts of lime, (5) less frequent cleaning of lime deposits from screens supporting the filter cloth on the vacuum filters and in the piping handling the filtrate.

Total costs for sludge filtration for 1939 per ton of dry solids based on dry solids in the filter cake at the Westerly and Southerly plants were $5.97 and $4.92, respectively. Based on dry solids in wet digested sludge these values were $7.51 and $5.70. Sludge incineration costs on similar bases were $5.10 and $6.41 at the Westerly plant which is equipped with two, six hearth incinerators, and $3.86 and $4.49 at the Southerly plant which is equipped with four, eight hearth incinerators.

Operation and cost data for both plants are tabulated in detail in five tables which cover the 1939 and January–June 1940 period.

Four charts relating to sludge filtration and one incinerator flow sheet are included.

Military Sanitation and the Sanitary Corps, by W. A. Hardenbergh, pp. 48–53. The Sanitary Corps is one of seven components of the Medical Department of the Army. At present the Corps consists of about 500 commissioned officers ranging in rank from First Lieutenant to Colonel. There is no enlisted component and no regular army component since it is composed wholly of reserve personnel. The duties of the corps include assignment with Corps Area Service Commands to advise the Surgeon in regard to problems of sanitation, service as assistant medical inspectors and sanitary engineers, laboratory work, assisting medical officers in the routine non-medical work of the army, advising in regard to sanitary matters in the selection of camp or training sites or areas, service with troops with water supply and purification units. A unit of Sanitary Corps officers will serve in the same general manner in the office of the Surgeon General.

Rotary Distributors on Sand Filters, by H. A. Stepleton, pp. 54–58. This paper describes the use of rotary distributors for distributing settled sewage over sand filters at two Allen County Ohio institutions. Both filters were 36 ft. in diameter by 2 ft. deep, the sand having an effective size of 0.3 to 0.45 mm. and a uniformity coefficient not greater than 3.0. The depth of graded gravel varies from 8 in. to 12 in. Primary treatment is obtained by a conventional type septic tank which provides a 12 hr. detention time at average flow. The dosing tank is of such capacity as to permit an average of only four dosings per 24 hours.

The cost of a conventional type sand filter unit would have been $3,000. By employing the rotary distributor the complete unit was built for $1,740.

One photograph, two tables of analytical data and one of cost data.

The Safety Aspects of Sewage Treatment, by Ben H. Barton, pp. 59–64. The most glaring safety inconsistency in sewage plants visited by the author has been the provision of explosion proof motors for units located in digester control houses, together with unguarded single-phase motors to operate sump pumps, circulating pumps and ventilating fans. The "plug in" type of unit is not recommended.

The need for guard railings was noted at many plants.

Cross connections between potable water supply lines and sewage pumps and boilers are a real hazard.

Enforcement of the State Health Department regulations governing operating personnel, regulation of hours and wages, and employment of licensed designers should provide greater safety in construction and operation.

Experiences with Chlorine in the Control of Activated Sludge Bulking at Mansfield, by J. R. Turner, pp. 65–69. Chlorine has been used at Mansfield: (1) In quantities as large as 300 lb. per day (20 p.p.m.) to break up *Sphaerotilus* during reactivation of badly bulking sludge; (2) in regular daily doses of about 50 lb. (10 p.p.m) to retard development of *Sphaerotilus* below the point of severe bulking; (3) in doses of 150 lb. per day (20 p.p.m.) added to return sludge when bulking is severe to break up *Sphaerotilus;* and (4) to supplement air during a period when a blower was down for repairs.

It is concluded that chlorine has aided very materially in preventing the bulking of activated sludge and in restoring sludge to normal after severe bulking.

Two charts. Paper is discussed by E. E. Smith and J. R. Collier.

Routine Sampling and Analysis in Ohio Sewage Treatment Plants, by L. T. Hagerty, pp. 70–74. Answers to fifty questionnaires sent out regarding sampling schedules and methods are tabulated. Answers indicate that no two plants take and handle samples in the same way. There is, therefore, little basis for the comparison of data from the various plants.

The Effect of Milk Waste on Sewage Treatment at Marysville, Ohio, by Earl F. Wittmer, pp. 75–82. The village of Marysville found it necessary to revise its sewage treatment plant in order to handle the combined municipal sewage and industrial waste load. The revised plant operation was studied and considerable operating data obtained. It is concluded that peak loads have been handled satisfactorily by two-stage trickling filtration following primary treatment. This type of filtration is feasible for reducing the B.O.D. of exceptionally strong sewage to a strength suitable for application on sand filters. Two-stage filtration also provides greater nitrification with heavier loadings and removals than single stage. Single stage filtration is used during the season of normal flows and two-stage filtration during the season of strong flows. Fourteen tables of analytical and flow data.

Report of Committee on Short Course Schools for Sewage Treatment, by M. W. Tatlock, pp. 83–85. This paper mentions the activities of various states in connection with short schools for sewage plant operators and reviews Ohio's efforts along this line. As a conclusion to this discussion the author presented a resolution to the Conference requesting the Ohio Health Department to give consideration to the organization of short schools for operators. The resolution was approved. (See pp. 11–12.)

Estimation of Water Used for Cooling at Lima, Ohio, by E. E. Smith, pp. 86–90. Normal water consumption has averaged 4.474 M.G.D. corresponding to 105 G.P.C.D. from 1930–1940. Sewage flow averaged 5.030 M.G.D. Excess sewage flow over water use averaged about 0.56 M.G.D. Excess flows of 1.12 M.G.D. and 0.93 M.G.D. were noted in 1939 and 1940, respectively. The lower excess in 1940 corresponds to lower air temperatures. Three charts are included which show mean air temperature, precipitation, excess sewage flow, and an estimate of the amount of this excess which was derived from private cooling systems.

Report of Committee on Corrosion, by Willard F. Schade, pp. 91–92. A review of the committee's work during 1940 followed by a general discussion of various corrosion problems.

News from Ohio Sewage Plant Operators' Sectional Groups, by W. D. Sheets, pp. 93–94. A summary of the activities of the sectional conference groups.

Autobiography of A Sewage Treatment Plant, by W. B. Nagel, pp. 95–98. A six year history of a sewage plant.

The Calendar and Clock Have Much to do with Catch Sampling, by W. F. Crohen, pp. 99–103. The author concludes from a careful study of analytical results obtained at the Findlay, Ohio, plant that occasional catch samples are unsatisfactory and should not be used as a basis for determining plant efficiency. Because of wide variations in solids concentrations from hour to hour throughout the week and from month to month, only composite samples should be used.

GROUP DISCUSSIONS

Maintenance of Sewage Works, reported by Earl Hoover, pp. 104–105. A discussion of maintenance on the basis of its benefits in the protection, the efficient operation of equipment, and the safety of plant personnel.

It was generally agreed that maintenance of adequate temperatures in gas-fired boilers would materially reduce corrosion troubles.

Toledo experience has indicated that tar-base black paint is suitable for underwater protection and asphalt-aluminum paint is suitable for equipment exposed to corrosive gases.

At one plant old dosing tank piping has been replaced with nickel alloy pipe.

Gummy deposits on chlorinator control parts may be removed by carbon tetrachloride.

Frequent replacement of comminuter teeth and combs is essential to efficient operation. Use of graphite grease on replacements will make subsequent removal easier.

Activated Sludge Treatment, reported by W. H. Jacobs, p. 106.

Sewage Filtration, reported by C. D. Yaffe, pp. 107–108.

Sewage Sludge Treatment and Disposal, reported by J. H. Wenger, pp. 109–111. At one plant a difficult problem resulted from the heavy solids in the digester supernatant. This was overcome by treating the digester with lime and filter alum.

Paul D. Haney

TURBULENT FLOW OF SLUDGES IN PIPES

By H. E. Babbitt and D. H. Caldwell

University of Illinois Bulletin, 38, 13 (November 19, 1940), 44 pages

This bulletin presents the results of an investigation, the object of which was to formulate the factors affecting the turbulent flow of sludge, and, if possible, to present, for various types of sludge, data which could be used in the design of pipe lines and pumping machinery for conveying various types of sludge. In order to test the validity of equations developed of turbulent flow, it was necessary to carry the tests to velocities of flow far above those normally encountered in practice. The apparatus to do this required the use of pumps and power of other types than those usually used for sludge pumping. A complete summary of nomenclature used in flows of this type is included, as well as a summary of the system of units used. Many engineers become somewhat confused over units of measurement, and it might be well to recall those used in this research: for mass, the mass pound; for force, the force pound; for length, the foot; and for time, the second. The mass pound is equivalent to the pound avoirdupois. The force pound is the force which will give one mass pound an acceleration of 32.1740 ft. per sec., regardless of the value of gravity in the locality. A mass pound is equivalent to a slug in the gravitational system, divided by 32.1740. A force pound is equivalent to 32.1740 poundals in the absolute system of units.

Formulas are presented for the determination of the upper and lower critical velocities dividing laminar flow from turbulent flow or fluid. It has been shown that the velocity at which the change from laminar to turbulent flow takes place may occur between the lower and upper critical velocities, and is controlled by various factors, the principal one being the roughness of the pipe.

In order to obtain a sludge whose characteristics would remain constant throughout all the tests so that comparable results might be obtained in different size pipes, it was found that a ball clay, mined in Tennessee, most nearly satisfied the requirements. The clay remained in suspension for several hours, and did not exhibit colloidal properties to such an extent that the yield value and coefficient of rigidity of the sludge were obscured. After the preliminary relationships had been established using the ball clay, a sewage sludge was obtained and tests were made on it to show the applicability of the relationships to different types of sludge. A graph is presented to show the relationship between the yield value and the concentration of suspended matter for this clay.

Because the clay was usually circulated for from three to four hours during a test, it was necessary to have a material which did not exhibit thixotropy. This is the property, or phenomenon, exhibited by some gels of becoming fluid when shaken. The change is also reversible. During several repetitions of runs at various periods of time, the friction losses for a constant velocity were constant, regardless of the amount of agitation of the sludge. It was concluded, therefore, that the clay mixtures used were not thixotropic. Because of the nature of sewage sludge, it might be expected that it would exhibit thixotropy.

The apparatus designed for this work had to meet the following requirements in order to establish the relationship between the factors involved in turbulent flow: (*a*) to deliver sludge to the upstream end of the test pipe at any desired velocity ranging from velocities less than critical to velocities well above those normally encountered in practice; (*b*) to maintain an even rate of flow of sludge in order to avoid fluctuations in head loss; and (*c*) to develop sufficient pressure to force the thickest sludge through the test pipe at velocities of 35 feet per second, or less. The limiting velocities chosen were approximately 0.5 feet per second to 35 feet per second; to obtain such velocities in the 1-in., 2-in., and 3-in. pipes tested, rates of flow between one gallon per minute and 500 gal. per min. were required. A gasoline engine was used to drive a set of pulleys through belts connected to five rotary pumps, each having a capacity of 100 gal. per minute at 300 r.p.m. The pipes through which the sludge was pumped ranged in size from ½ in. to 3 in. in diameter. All pipes were new standard black steel taken from stock. Test lengths were 21 ft. for the 1-in., 2-in., and 3-in. pipes, and 10 ft. for the ½-in. pipe. The lengths of pipe upstream and downstream from the test length were at least 40 pipe diameters, assuring steady flow conditions through the test length. The interiors of the pipes all appeared appreciably smooth with little apparent mill scale. As a protection against corrosion throughout the duration of the tests, disconnected test pipes were kept full of sludge and the ends securely closed. The rate of flow determinations were made by weighing the sludge, knowing the density of the material.

Data and methods involved are presented for the determination of Reynolds' number, the critical velocity, yield value, and other essential characteristics of the sludges. It was found that the following factors affected the friction loss of sludge in straight, circular pipes flowing full with a constant average velocity: (*a*) diameter of pipe; (*b*) velocity of flow; (*c*) length of pipe; (*d*) roughness of pipe; (*e*) density of the flowing sludge; and (*f*) yield value and coefficient of rigidity of the sludge. Characteristics of the sludge and its environment, such as particle size, concentration of suspended matter, temperature, etc., will probably affect the friction losses, but may be considered only in their effect on the yield value and the coefficient of rigidity of the sludge. It was found that for sludges composed essentially of water with suspended material the viscosity of the dispersion medium is nearly the same as that of the water, so that any other common hydraulic formulas can be used in finding the turbulent flow friction losses of a sludge. Data are presented to illustrate the validity of this conclusion. This occurs because the viscosity of the dispersion medium of the sludges is essentially the same as that of water. It was further observed that the head loss due to the turbulent flow of sludge is independent of the rigidity and the yield value of the sludge. Since water is the dispersion medium in the sludges tested, it follows that the head loss due to the turbulent flow of sludge in which water is the dispersion medium is dependent on the characteristics of the water. This data is corroborated by considerable data which show that sludges with the viscosity of the dispersion medium the same as that of water, and with a density closely that of water, will have a friction factor for the sludge closely equal to the friction factor for water at equal velocities. It was also noted from the data obtained that a relatively large difference in Reynolds' numbers will cause a relatively small variation in the friction factor. Since all factors in commonly-used hydraulic formulas are the same for water and for sludges with water as the dispersion medium, the head loss resulting from the turbulent flow of sludge with water as the dispersion medium is the same as that for the flow of water.

Data are presented to show that for ordinary sludges the diameter of the pipe has a negligible effect on the critical velocity for pipes larger than 2 to 3 in. in diameter. Above a diameter of 3 in. the critical velocity remains nearly constant for a given sludge. This conclusion is in contrast with what occurs in the case of the critical velocity of a true liquid, which varies inversely as the pipe diameter, as shown by the Reynolds' criterion. Data are also presented to show that the effect of roughness on critical velocity is of considerable magnitude.

The authors conclude that most sludges, such as drilling muds, clay slurries, sewage sludges, and other aqueous suspensions of fine particles, when flowing in a pipe at a velocity greater than the critical, follow the fundamental laws for the flow of true fluids. Problems involving the head loss due to friction resulting from the flow of sludges at greater than critical velocity can be solved by means of charts compiled by the authors, or for certain types of sludges, by means of the familiar exponential formulas, such as those of Hazen and Williams, Saph and Schroeder, Kessler, and many others. In order that such formulas may be applied, the sludge must be made up of finely-divided substance dispersed in water, and the velocity of flow must be above the critical.

ROLF ELIASSEN

ADVERTISERS' CONTRIBUTIONS

This special section has been prepared in order to give our advertisers an opportunity to describe their products and new developments in sewage treatment practice. We have never published the usual run of advertising agents' items concerning the products and equipment advertised in our Journal, *but in view of the large number of exhibitors at the New York Convention, most of whom are our advertisers, we decided, largely on the suggestion of Mr. A. A. Clay, our Advertising Manager, to run a special section in this issue.*

The contributions, in most cases, have been prepared by engineers of many years' experience in sewage treatment work. The articles therefore are of more interest and authority than the usual advertising arguments.

This use of our valuable space, otherwise devoted to technical papers, was offered gratis to our advertisers because of the special nature of this issue, just prior to the Convention. It is an expression of our recognition of the advances in the art of sewage treatment made by the manufacturers in this field, as well as appreciation of the continued support they have given our Journal *and the* Federation. *If any advertisers have been too late to be included in this issue, their contributions will be published in our November issue.*

F. W. Mohlman, *Editor.*

ALUMINUM COMPANY OF AMERICA

Pittsburgh, Pa.

EXPANSION FOR DEFENSE

According to a recent announcement by W. S. Kundsen, the expanded plane program of the United States will require an annual production of 1,600,000,000 pounds of aluminum. The best available estimates indicate that this is more aluminum than the whole world produced in 1940.

Aluminum production in the United States during 1939 was 327,000,000 pounds. Domestic production at present is at the rate of nearly 600,000,000 pounds annually, and by July 1942, will reach 825,000,000 pounds per year. Until recently, Aluminum Company of America was the sole producer of primary aluminum in this country, and by July of 1942 it will have completed a national defense expansion program which will more than double the production built up over a half century of operation.

Vancouver, Washington, Works

The first plant in ALCOA'S expanded program went into complete operation May 29, 1941. This date marked the completion of the fifth unit of the Vancouver, Washington, plant, bringing the total capacity of this plant up to 150,000,000 pounds per year. In March 1940, the site now occupied by the new works was a cow pasture (Fig. 1). Now the completed works is producing 150,-000,000 pounds of aluminum per year (Fig. 2).

This figure is highly significant when one considers that the total production of all aluminum in the United States did not exceed 130,000,000 pounds per year in the last world war, and that the entire industry in the United States did not produce 150,000,000 pounds a year until 1924.

FIG. 1.—Cows were grazing contentedly on this Columbia River farm, near Vancouver, Washington, on March 9, 1940, when this picture was taken.

The construction of the Vancouver works is part of an expansion program which approximates $200,000,000. When the program is completed in midsummer, 1942, Aluminum Company of America will be able to more than double its peak peacetime production of 1939, when more than 327,000,000 pounds of aluminum were made.

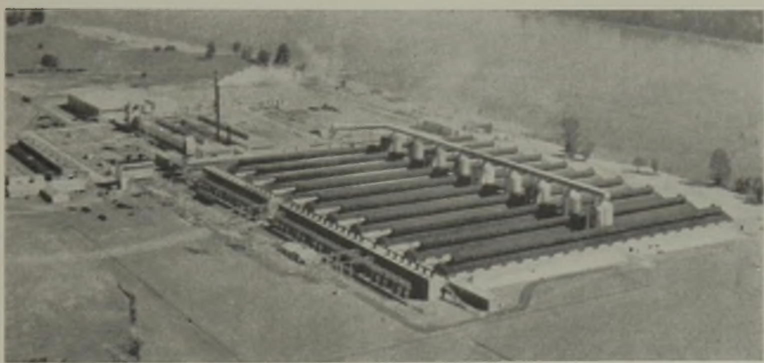


FIG. 2.—And now look at the cow pasture! The time is May 29, 1941, 15 months after the cows were evacuated. Five metal-producing units, each capable of producing 30,000,000 pounds of aluminum a year, are in operation.

The Vancouver Works is one of five aluminum-producing plants of the Aluminum Company of America. In addition to these, the company has 12 other plants in which the metal is processed.

Since more electricity is consumed in the production of aluminum than in any other industry, large amounts of electrical power are needed. Power contracts for the Vancouver Works were signed with the Bonneville Power Administration for a total of 162,500 kilowatts.

Vernon, California, Works

In 1937, in order to serve the airplane industry more effectively, the company bought 15 acres of land in Vernon, a section of Los Angeles, and erected on it a sand and permanent-mold foundry and forge plant. The works was completed early in 1938. At the start of the war, the Vernon works had a capacity of 100,000 pounds of aluminum alloy forgings, and 424,000 pounds of sand and permanent-mold castings a month.

In the spring of 1940, an expansion of our facilities in Vernon was announced. This expansion included the addition of an extrusion works and a rivet plant, as well as additions and betterments to the existing aluminum foundry and forge plant. To carry on this expansion, the company acquired an adjacent 30 acres of land.

Fig. 3.—Los Angeles. Approximately 17 per cent of the aluminum going into military planes today is in the form of forgings. Aluminum Company of America has almost trebled its forging capacity at its four forging plants. At Vernon, in the midst of the airplane industry on the West Coast, there has been a 350 per cent increase in capacity. A row of 11 of the 21 hammers in that works is shown above.

The buildings necessary to house the additional fabricating facilities in Los Angeles have now been completed and the equipment is rapidly being installed to handle the increased production, so that very shortly the sand and permanent-mold casting capacity will have been increased to 593,000 pounds a month (an increase of 40 per cent), and the forging capacity (Fig. 3) to 450,000 pounds a month (an increase of 350 per cent); while the new extrusion plant will be turning out extruded shapes at the rate of 1,019,000 pounds a month; and the new rivet plant, rivets at the rate of 70,000 pounds a month. By March 1942, the forging capacity of the Vernon works will have been increased an additional 50,000 pounds a month. In terms of floor space, the works has been expanded in size from 100,000 sq. ft. at the start of the war to 555,000 sq. ft.

Lafayette, Indiana, Extension Works

The Lafayette (Ind.) works of the company is also a fairly new plant. One hundred and eighty acres of land was acquired just southeast of Lafayette, and an extrusion plant and tube mill (Fig. 4) were built on this site and placed in operation in January, 1939.

When hostilities broke out between Great Britain and Germany in 1939, the Lafayette works had a capacity of 695,000 pounds of extruded shapes and 122,000 pounds of tubing a month. By October of this year, the floor space in the Lafayette works will have been increased from 287,000 sq. ft. to 1,471,000 sq. ft. (an increase of 413 per cent); and by December, the extruded shape capacity will have been expanded to 4,256,000 pounds monthly (six times the capacity in 1939), and tubing capacity will have reached 1,034,000 pounds a month (nine times the capacity of 1939); however, by April 1942, the tubing capacity will have been expanded to 1,348,000 pounds a month (eleven times the capacity in 1939).

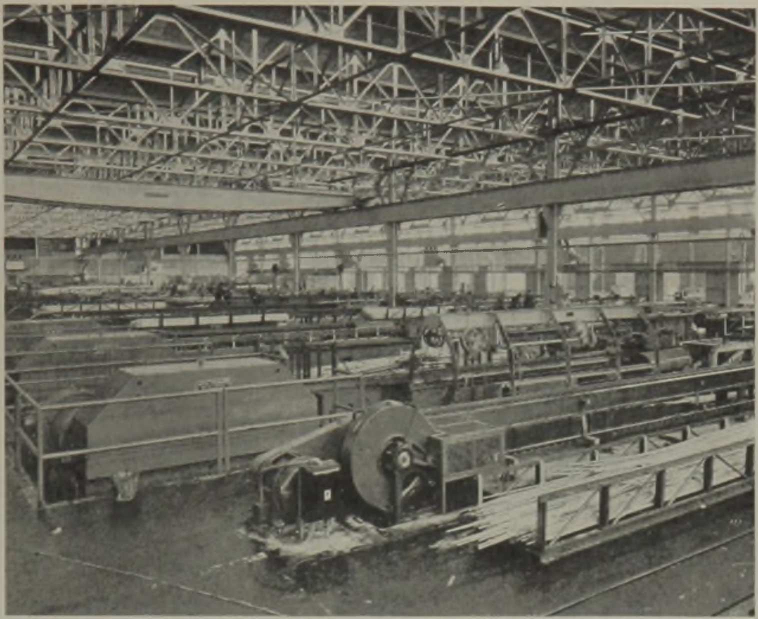


FIG. 4.—Lafayette, Ind. Aluminum tubing for defense. This mammoth works has been expanded fivefold since hostilities began between Great Britain and Germany. Tubing is being produced on a 20-shift-a-week basis for use in aircraft, naval vessels, signal equipment and other defense needs of the government. Production capacity will by the end of this year be nine times greater than at the start of the war.

The expansions and improvements at Los Angeles and Lafayette are part of Aluminum Company of America's $200,000,000 expansion program which the company has undertaken in order to supply defense industries with aluminum ingot and fabricated products. The program, which is entirely self-financed, crowds into two years the equivalent of at least two decades of peace-time growths.

Fig. 2.—Wards Island Sewage Treatment Works, showing filters for air used in activated sludge treatment. Frame work, holders and mesh are welded and bolted Everdur sheets and strips.

troughs, screen hoppers, orifices, baskets, anchors, ladders, float gauge chain, valve springs, manhole steps, guides, walkways, bars and plates (Fig. 2), bolts and nuts, electrical metallic tubing and rigid conduit.

THE AMERICAN WELL WORKS

Aurora, Ill.

CENTRIFUGAL PUMPS, DEEP WELL TURBINES, SEWAGE PUMPS, SLUDGE PUMPS, SEWAGE AERATORS, ROTARY DISTRIBUTORS, AXIAL FLOW PUMPS, SLUDGE COLLECTING MECHANISM

BIO-ACTIVATION PROCESS

(Combination Biological Filter and Activated Sludge)

For several years the American Well Works has been working on the development of an activated sludge process that would produce a stable crystal clear effluent even when the influent sewage possessed characteristics that would stress or upset a standard activated sludge plant.

We had long observed the ideal operating condition that existed at Cedarburg, Wisconsin, where the plant, even when handling the tremendously great shock loads of a large pea cannery, always produced a stable effluent of highest quality. The Cedarburg plant is a two-stage trickling filter and slow sand filter process, with short settling period between. During times of normal load, the plant is operated as a standard rate trickling filter and during adverse conditions the trickling filter became a high capacity filter (see curve) and the settled filter effluent is pumped onto a slow sand filter loaded in accordance with the reduced trickling filter effluent B.O.D.

The advantages are the dependability and completeness of treatment. The disadvantages are the high cost of construction and labor required to keep the sand beds clean.

Accordingly, we substituted the activated sludge process for the second stage (in place of the slow sand filter) and developed the Bio-Activation Process (Fig. 1) that can be depended upon under all conditions, will produce an effluent equal to the slow sand filter, and is both economical of construction and operation.

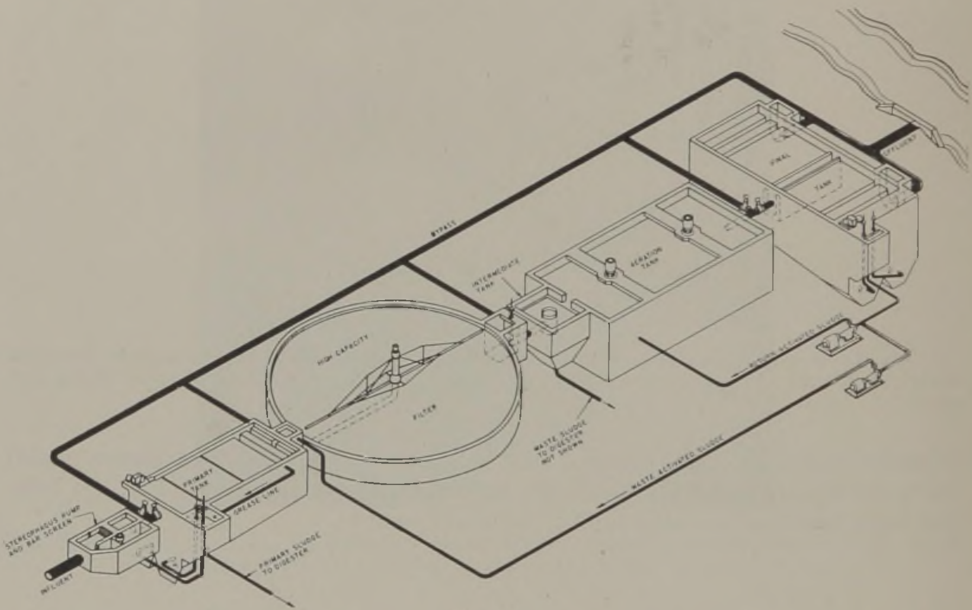


FIG. 1.

The Bio-Activation process is a combination in two stages of trickling filter and activated sludge in such a manner that each stage operates under optimum conditions and at maximum efficiency.

Trickling filters do practically all of their work in the first 2 or 3 feet depth of media and the remaining volume of media serves to accomplish a relatively small additional amount of work in the removal of B.O.D. and serves only to "polish" the effluent. It is a well established fact that a trickling filter is a very "tough" sewage treatment agent and is capable of handling shock loads, high strength sewages and septic sewages without the upsetting tendency of a straight activated sludge process. Also it has been observed that when a trickling filter is abused, or overloaded, it will always produce an effluent of reasonably good quality provided, of course, the trickling filter is properly constructed.

The activated sludge process is highly efficient but results are sometimes unpredictable and during periods of dry weather flow or during periods when any unusual industrial waste is dumped into the plant, the process is apt to "fold up" entirely. Under ideal conditions (when it is handling a fresh dilute sewage containing dissolved oxygen, with no trace of septicity) it will deliver a high quality, stable effluent which is second to none.

In the bio-activation process, the best qualities of both the trickling filter and the activated sludge process are combined in such a manner that they work symbiotically to obtain the best results and the greatest efficiency from each. A relatively small amount of media is used in the trickling filter so as to obtain that first high efficiency of B.O.D. removal. Complete treatment is not attempted in this unit. The partially oxidized and very fresh trickling filter effluent is passed into the aeration tanks and treated by the activated sludge process. Under ideal conditions the activated sludge process is absolutely dependable and not subject to continual upsets.

Plant Design

It is desirable to dose sewage over the surface of the high capacity filter in such a manner that there will not be more or less than 15 second intervals between doses to each unit area. It is recommended in order to accomplish this that a positive drive distributor be used. If a positive drive distributor is not used, it will be necessary to employ recirculation through the filter in order to obtain the same conditions (Fig. 2).

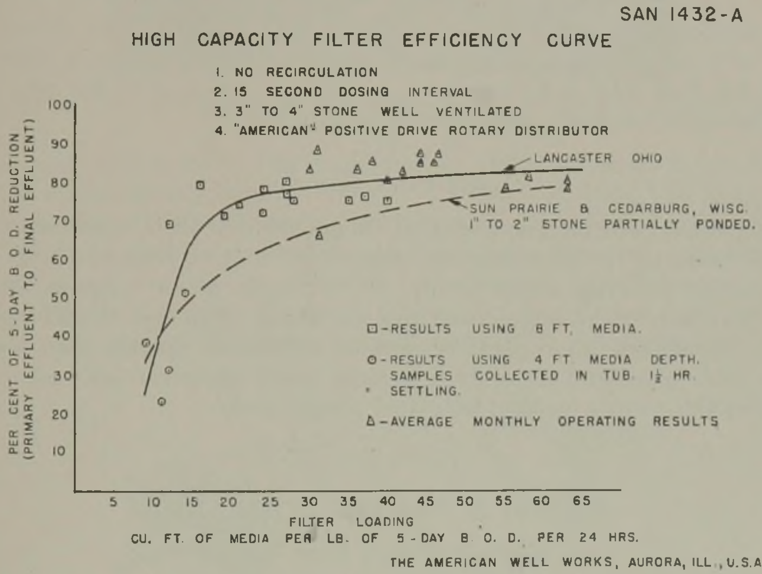


Fig. 2.

The aeration tank is designed on a relatively short detention period. This is all that is required because of the reduced strength and *treatability* of the sewage coming from the trickling filter. Also, no excess capacity is required to handle shock loads such as is the case where an activated sludge plant treats settled sewage. It has been demonstrated that it is feasible to treat fresh sewages running from 75 to 80 B.O.D. with an hour to an hour and a half retention period in the activated sludge tanks. The sewage coming out of the high capacity filter and entering the aeration portion of the process is comparable to very weak sewage, with one distinction. That is, the sewage that comes from the trickling filter has been started on the road to complete oxidation and is even *more easily treated* by an oxidation process than would a sewage that has not received such a pre-treatment in a biological filter.

Cost of Construction

In observing the design of a good many plants, it has been found that plants of this type are about equal in construction costs to straight activated sludge plants and are much less than straight trickling filter plants. We feel that the design factors used at the present time are probably even more liberal than is necessary since present results indicate that even less filter media and aeration tank capacity could be used. Therefore, construction costs can probably be still further lowered without any sacrifice in plant efficiency.

Cost of Operation

Experience in operating this type of plant indicates the power requirements for the process amount to about 15 kilowatt hours of energy consumption per day per thousand population equivalent served by the plant. This does not include energy used for scraping mechanisms, sludge pumps, etc., but only includes the energy used for the operation of the aeration units in the activated sludge portion of the plant and the return of activated sludge. By comparison, a straight activated sludge plant will use from 40 to 50 kwh. per day per thousand population served.

It is interesting to note that no recirculation through the high capacity filter is used, with the exception of the waste activated sludge, which is passed back through the filter unit and amounts to less than 5 per cent of the total sewage flow. Therefore, no costly recirculation is required.

Laboratory Control

Bio-activated plants are so stable and dependable in their operation that it is much less necessary to have elaborate laboratory control of these plants than it is of a straight activated sludge plant. Of course, we do not mean to imply that it is not necessary to keep operating records which, of course, should be kept in all cases. A bio-activation plant is no more difficult to operate than a straight trickling filter plant and certainly it is much easier to operate and more rugged and dependable than a straight activated sludge plant.

RALPH B. CARTER COMPANY

53 Park Place, New York

SLUDGE PUMPS—FLOCERS—CONDITIONERS—MIXERS—FILTERS—AERATORS—SIPHONS—WATER SYSTEMS—SELF-PRIMING CENTRIFUGAL PUMPS—HUMDINGER PUMPS

Many of our special heavy duty sludge pumps are in use by the City of New York. The pump shown in Fig. 1 was installed about 1937 in the Tallmans Island plant. We have eight similar units at Tallmans Island and since that time have been working closely with the Dept. of Public Works, New York, Div. of Engineering, and have brought out a sludge pump of very heavy construction, operating at 115′ TDH. Most of these units are of the triplex type, although there are a number of the duplex type construction. The triplex type are usually of capacities ranging from 180, 120, 80, and 60 GPM., adjustments in capacities being obtained by means of two-speed gear reducers and two-speed motors. The motors used on the Triplex pumps are 15 hp. two-speed, totally enclosed type.

We also make a portable gasoline driven, 6 in. triplex sludge pump, which is used extensively by the Dept. of Public Works, New York City. This pump was used on the New York City sludge barges for auxiliary pumping purposes.

We are developing a new disc-type flocculator, on which we are running several tests at the present time.

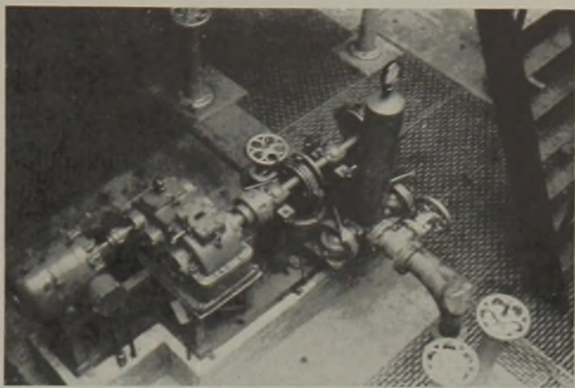


Fig. 1.—Carter sludge pump at Tallmans Island Sewage Treatment Works.

The construction of a Carter Flocer is shown in Fig. 2. A horizontal shaft (or shafts) placed longitudinally in the flocculation tank is rotated by the usual form of driving mechanism. On this shaft are spaced a series of circular control plates known as controllers, each having a cutaway segment through which the majority of the liquid under flocculation treatment passes.

With the shaft at rest the liquid undergoing flocculation treatment will in the main pass through the open segment portions of the controller plates thus

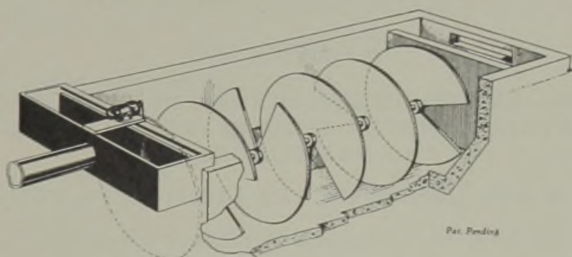


Fig. 2.—Carter Flocer now under development.

forming a tortuous path from entrance to exit; under the first controller, across and through the second controller, up and through the third controller, down and through the fourth controller and so on. As the liquid passes through each segment its velocity is materially increased and can be definitely controlled by the size of the segment. This increased velocity sets up multitudinous eddy currents immediately in back and in front of the open segment, while the liquid both before and behind the solid section of the controller plate is in a comparative state of quiescence.

Under this condition the flocs in suspension in the liquid will settle from the comparatively quiescent zone either to the bottom or into the zone of comparative turbulence, preceding and immediately beyond the open segment section. By slowly rotating the controller plates, an everchanging flow path is created throughout which are set up an infinite number of eddy currents of any desired velocity and size, through control of the opening through the control plates. Floc settling in the zones of comparative quiescence immediately before and in back of the solid portions of the control plate are, by rotating the plates slowly, shortly in a zone of turbulence where they are carried by the increased velocity into the next zone of quiescence and intermingled with other flocs without destructive agitation.

They are then, with these other flocs of an ever increasing size, allowed to settle until the subsequent control plates' open segment arrives at that portion of the tank, where they are again swept up by the increased velocity and carried on to the next zone of quiescence preceding the next control plate, in this way not only effecting a most complete mixing but also completely eliminating any tendency toward breaking up of the larger newly formed flocs toward the latter end of the flocculation tank, such as usually occurs with the paddle agitator as it strikes these newly formed flocs in its path of rotation.

We have numerous installation of the standard paddle-type flocculators, one of the outstanding installations having been installed last year at the Miraflores and Mt. Hope water plants at the Panama Canal, and at the Hackensack, N. J., plant.

Another important development in our company during the past year has been the completion of arrangements with Mr. W. C. Laughlin for the manufacture and marketing of his new approved rapid sand filter. We have recently completed installations at the New York Central Yards, Harmon, N. Y., and Ponds Extract Co. at Seymour, Conn., and are at present at work on several other installations in paper plants.

CHAIN BELT COMPANY

Milwaukee, Wis.

REX CHAIN, REX CONCRETE MIXERS, REX SPROCKETS, REX TRAVELING WATER SCREENS, REX ELEVATORS AND REX CONVEYORS

THE NEW AND IMPROVED REX LIGHT TYPE EQUIPMENT

Recognizing the need of mechanical equipment designed and built particularly for the small sewage plant, the Chain Belt Company now offers a mechanically cleaned bar screen, grit collector, and conveyor sludge collector, especially for this service. In designing these small plant units, nothing has been done to endanger the long life and low maintenance characteristics of REX equipment.

Introduced scarcely eighteen months ago, the REX Unistrand grit collector has rapidly made warm friends throughout the engineering profession, and has given complete satisfaction at its many points of installation. Now classified as types MI and MIN, the former will handle flows to 3.0 m.g.d., the latter, of similar design by lightened proportionately in all members, will handle flows to 1.5 m.g.d. Both types of units are of economical construction, and bring

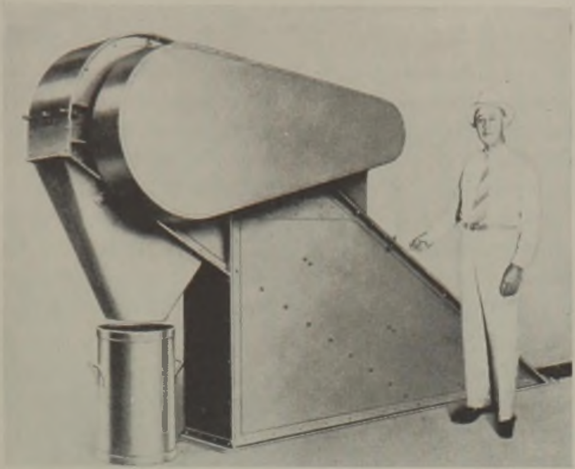


FIG. 1.—Head of REX Unistrand Grit Collector.

mechanical handling of grit within the realm of the smallest community, since the cost is little more, if any, than for dual hand cleaned grit chambers.

In addition to low cost of equipment, the economy is carried on into the actual construction of the channel. The simplicity of design makes possible the use of cast iron pipe, terra-cotta pipe, or open channels for influent and by-pass lines. The channel receiving the equipment is usually of concrete, but in special cases steel may be used.

As in all types of REX grit collecting equipment, the Unistrand employs the important and exclusive REX principle of recirculation. Positive control

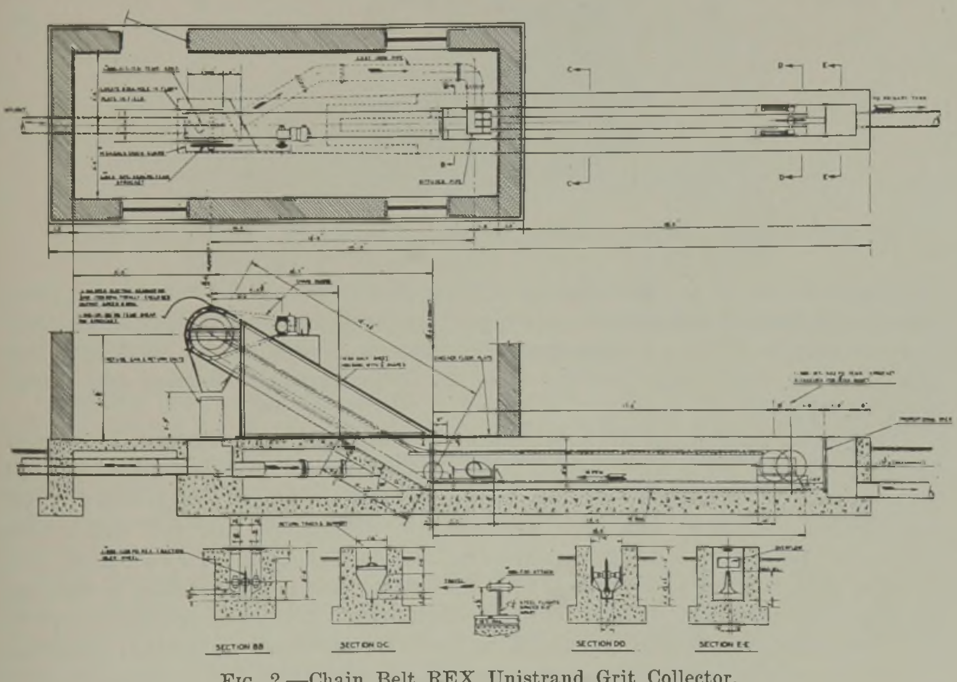


FIG. 2.—Chain Belt REX Unistrand Grit Collector.

of grit quality is provided through this means of recirculation. If poor quality grit, containing a high percentage of organics which settled out during low flows, is being removed from the chamber by the mechanism, it can be returned directly to the sewage stream at times of normal flow. By the time the grit again reaches the grit chamber, being carried there at a high velocity, it is well mixed with the incoming sewage. With favorable flow conditions existing, true grit will resettle and undesirable organics will be carried out of the channel. Velocity control is obtained by using a proportional weir, accurately designed to conform to the cross sectional dimensions of the channel.

The equipment itself consists of a single strand of corrosion-resistant, Z-metal, pintle chain, running over three sprockets on which are mounted a series

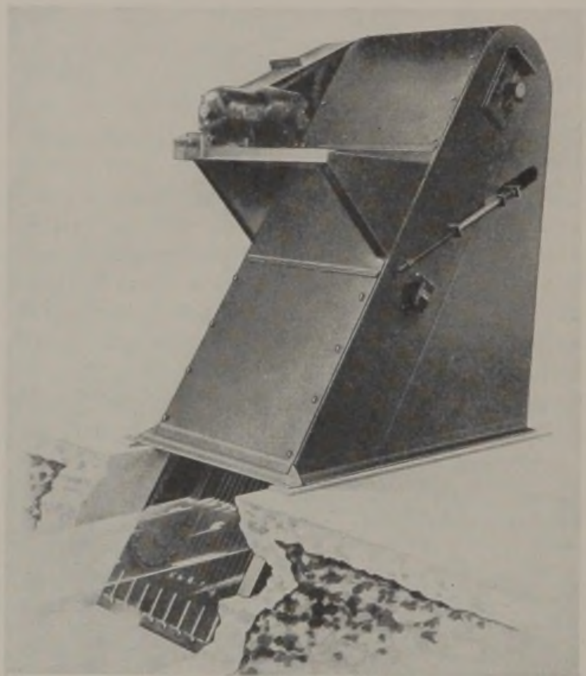


Fig. 3.—Chain Belt REX mechanically cleaned bar screen.

of scraper flights at suitable spacing. These flights collect the settled grit from the channel bottom and drag it up the inclined head section for disposal in cans, or recirculation. The accompanying illustrations show the head section of this unit (Fig. 1), and a line drawing (Fig. 2) indicating both channel and equipment construction.

The second unit of the REX MI family is the light type mechanically cleaned bar screen (Fig. 3). Here again, REX has pioneered and developed an important unit of sewage treatment that is within the reach of practically all communities. Nothing has been sacrificed in design, for all the well-known features of the larger REX screen are available in this unit. Unobstructed flow to rack, low head loss, Z-metal chain and attachments, rigid rake mounting, positive and quiet rake cleaner, split-head-sprockets, full housing—all are present. The difference lies in the use of lighter members, such as smaller diameter headshaft, smaller pitch diameter sprockets, smaller but fully enclosed drive unit, and smaller pitch chain. Screen chains are of the combination type, instead of pintle type.

The maximum capacity of this unit is approximately 3.0 m.g.d. It may be used in a channel of any dimensions up to 3 ft. wide and 8 ft. deep. Shipped generally as a fully assembled unit, installation becomes no problem. The unit is equally adaptable to installation in a new channel, or to replacement of a hand-cleaned bar rack in an existing channel. The Rex Triturator can be used in combination with this screen, if desired.

To complete the line of REX MI equipment, there is offered the light type sludge collecting equipment. With this unit, too, REX was first in the field, striving to provide an equipment item low in first cost and operating cost which would materially aid the small community in including mechanical sludge removal in its plant design.

In principle and design, the MI sludge collector is no different than the heavy duty collector. All the recognized advantages are available, including Z-Metal chain and attachments, pivoted flights, centralized wearing shoes, full width skimming, offset drive sprocket, self-aligning bearings, and totally enclosed drive unit. To gain economy in construction, it was necessary to lighten all members proportionately, not however, impairing the strength and adequacy for the purpose intended. The MI collector uses smaller diameter shafting, smaller pitch diameter sprockets, smaller wood or steel scrapers, smaller pitch chain, lighter wearing shoes (because of less load), lighter tee rail, and less horsepower.

Because a smaller pitch chain is used, a takeup shaft is not required, for chain slack can easily be taken up by removing the necessary links. This eliminates the expense of takeup bearings.

The maximum size tank in which this type of equipment can be installed is 10 ft. wide by 50 ft. long. The popularity which this particular unit enjoys is evident in the fact that there are now many installations, placed through leading consulting engineers, all in successful operation.

CHICAGO PUMP COMPANY

2336 Wolfram Street, Chicago, Illinois

VACUUM, CONDENSATION, CIRCULATING, BILGE FIRE, HOUSE, SEWAGE, SCRU-PELLER PUMPS, AERATORS, COMMINUTORS, SAMPLERS

WASTE SLUDGE CONTROL IMPROVED IN "CHICAGO" COMBINATION AERATOR-CLARIFIER

Positive and automatic waste sludge control has been developed by the Chicago Pump Co. for its combination Aerator-Clarifier. This equipment performs the aeration, clarification and waste-sludge control phases of the activated sludge process in a single tank. It effects purification to 98 per cent removal of contaminating organic matter, requiring less than two hours manual supervision daily.

The combination Aerator-Clarifier makes it possible for small municipalities and institutions to obtain the advantages of the activated sludge process for the complete treatment of their sewage at lower construction cost than any other method of complete sewage treatment.

"FLUSH-KLEEN" IMPROVED

The inflow capacity of Chicago Pump Co. "Flush-Kleen" sewage ejectors has been greatly increased by placing a by-pass to the wet basin between the automatic strainer and the pump.

The sewage inlet is connected to the discharge pipe of the "Flush Kleen" instead of to the basin as in ordinary sewage ejectors; therefore, the raw sewage flows into the discharge line. A strainer just ahead of the pump stops the solids but allows the water to pass through the by-pass into the basin. The solids accumulate in the strainer chamber located in the discharge line of the "Flush Kleen." When the pump starts it pumps the water from the basin through the discharge line. As the water passes through the strainer chamber it flushes out the solids that have accumulated there. A check valve in the by-pass prevents sewage being pumped back into the wet basin and another check valve in the inlet prevents the sewage from being pumped back into the inlet line. These are improved check valves that eliminate the possibility of rocks holding them open. The new by-pass on "Flush-Kleens" also reduces the pump pit depth requirement by one foot.

COMMINUTORS IMPROVED

Improvements in the design of Comminutors, which cut up coarse sewage matter under water, have greatly increased the cutting capacity and the fineness of the cutting. At the same time, the cutting effort has been so greatly reduced that the motor horsepower required has been cut in half.

Several improvements combined make all this possible. First, the cutting, or shearing, and relief angles between the cutting members were increased, and the clearances between the cutting members were made closer. The action of the cutters is like shears.

The new model Comminutors have staggered cutters and staggered combs. This improvement has resulted in a smaller amount of material being engaged with the cutting members at one time but a greater number of cuts for each revolution of the slotted cylinder. On one machine there formerly were six major cuts per revolution; now there are forty-two. Instead of a few shock loads, there is now a continuous series of small, fine shearing actions.

A third cutting member, called a shear bar, has been added to the new Comminutors. It is a removable sharp-edged wearing insert. Several of these shear bars are mounted on the slotted cylinder in staggered positions. They shear stringy material that flows only part way through the slots. This prevents such abrasive-ladened material from wedging between the comb and the revolving cyclinder and wearing away the latter. With the shear bars the stringy material is cut immediately and is carried through the slots by the flow before the abrasives have had time to wear the cylinder. When wear does occur, only the wearing inserts need be replaced.

Similarly, the sharp, clean shearing action, due to the new cutting angles and close clearances between all cutting members, reduces the wear on all parts of the Comminutor.

Because of the improved cutting action, it has been possible to reduce the number of cutters on the new Comminutors, and thus lower the maintenance cost in replacing cutters.

The new cutting or shearing angles between the cutting members have been designed to eject hard material, such as iron and stone, but to retain and cut soft material which has a higher coefficient of friction.

Cutters have been redesigned to simplify sharpening so the operator can grind them at his plant.

All of these new features of the cutting members combined have so greatly improved the efficiency of the cutting, or shearing, of the Comminutor that it has been possible to reduce the motor horsepower required by half.

NEW SWING DIFFUSER DEVELOPED

Improvements in the "Chicago" Swing Diffuser make every part of the air diffusion unit accessible from the tank walk when in the raised position. Each unit can be removed completely from the aeration tank by means of an electric hoist. Tube inspection, maintenance and regulation of air supply can all be accomplished from the tank walk without dewatering the tank or interrupting operation.

Simplified construction makes the new model lighter in weight and easier to handle. There are two joints in the new model. A swing joint is mounted in the coping at the tank walk, and a knee joint connects the two sections of the hanger pipe. The hoist grips the upper section of the hanger pipe just below the swing joint and raises the unit to the tank walk similar to raising one's leg with his knee joint relaxed.

The "Chicago" Swing Diffuser was designed to operate on the tapered aeration principle of the activated sludge process of sewage treatment supplying oxygen to the mixed liquor in practical proportion to the oxygen utilization characteristics of the liquor.

The Tru-Test sewage sampler has been redesigned and improved by the Chicago Pump Co. to take samples automatically and accurately in proportion to the flow through the plant. It gives representative samples containing the correct proportion of suspended solids and dissolved organic matter. Samples can also be taken to show accurately the changes in character of the raw sewage during the day and the effectiveness of the various stages of treatment as the sewage passes through the plant.

In addition to the improvement in the accuracy of sampling, the parts of the sampler have been made more accessible and refrigeration for the samples can be installed for those who desire it.

The sampler can be accurately controlled by any one of the following three methods:

(1) By utilizing the difference in pressure through a flow meter.

(2) By the variation in the level of the liquid in the tank or channel.

(3) By manually setting the sampler to take samples at any desired frequency.

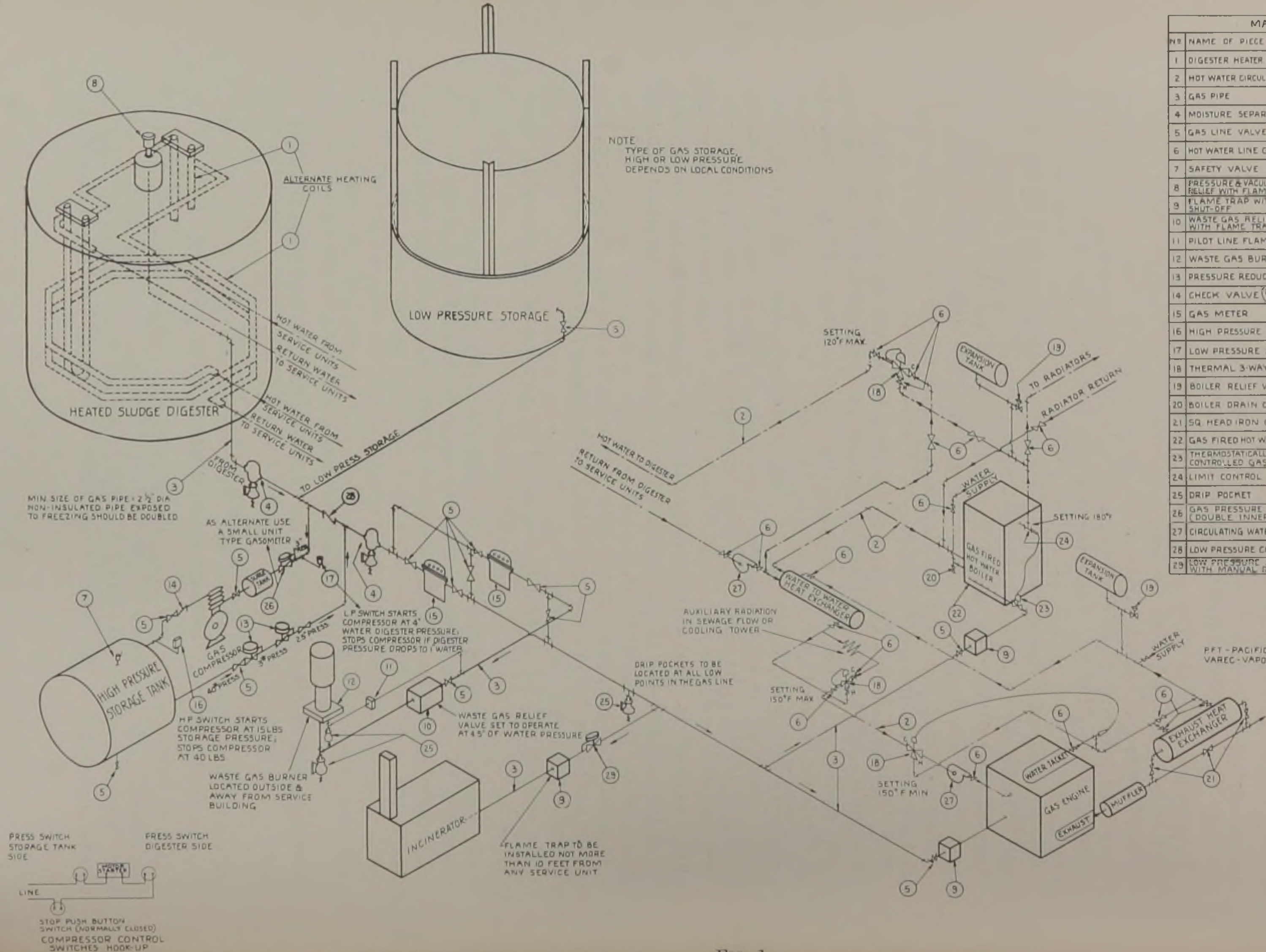
CRANE CO.

VALVES, FITTINGS, FABRICATED PIPE HEATING AND PLUMBING MATERIAL

836 So. Michigan Ave., Chicago

TYPICAL SEWAGE GAS UTILIZATION SYSTEM

One of the liveliest subjects in the present day sewage treatment field is the utilization of the methane gas evolved from the digesting sludge. Several sewage publications have printed symposiums and other current information on the development of this phase of the field. However, to date no attempt has



MATERIAL LIST

Nº	NAME OF PIECE	MATERIAL & SPECIFICATION Nº
1	DIGESTER HEATER COILS	MONOLOY THREADED C.I. PIPE OR G.W.I. PIPE-FED SPEC WW P-441a
2	HOT WATER CIRCULATING PIPE	
3	GAS PIPE	
4	MOISTURE SEPARATOR	CRANE CO Nº 41 CAT Nº 07
5	GAS LINE VALVE	MERCO NORDSTROM {Nº 133-4" & SMALLER / Nº 1143-6" & LARGER
6	HOT WATER LINE GATE VALVES	CRANE CO Nº 41 CAT {Nº 437-3" & SMALLER / Nº 461-4" & LARGER
7	SAFETY VALVE	CRANE CO Nº 41 CAT {Nº 1885-½ TO 1½ INCL / Nº 1114-SPEC 2" TO 4" INCL
8	PRESSURE & VACUUM RELIEF WITH FLAME TRAP	P.F.T. Nº 4D-266 VAREC FIG 58 C
9	FLAME TRAP WITH SHUT-OFF	P.F.T. Nº 4D-36 A VAREC FIG 450
10	WASTE GAS RELIEF VALVE WITH FLAME TRAP	P.F.T. Nº 4D-36 B ASSEMBLY VAREC FIG 440 ASSEMBLY
11	PILOT LINE FLAME CELL	P.F.T. Nº 4D-226 VAREC FIG 51 OR 52
12	WASTE GAS BURNER	P.F.T. Nº 4D-348 VAREC FIG 236
13	PRESSURE REDUCING VALVE	FISHER Nº 730
14	CHECK VALVE (CUSHION TYPE)	CRANE CO Nº 41 CAT {Nº 366-E OR / Nº 369-E
15	GAS METER	PITT. EQUITABLE METER CO-CAT 1031 P-3 AMERICAN METER CO-CAT EG40 P-15
16	HIGH PRESSURE SWITCH	CRANE CO CAT 614C-PG 202-2
17	LOW PRESSURE SWITCH	MERCOID CORP Nº 848 MOD C
18	THERMAL 3-WAY VALVE	POWERS REGULATOR CO-Nº 11
19	BOILER RELIEF VALVE	CRANE CO CAT 614C-PG 169-5 SIMPLEX A-2
20	BOILER DRAIN COCK	CRANE CO Nº 41 CAT Nº 250
21	SQ HEAD IRON COCK	CRANE CO Nº 41 CAT Nº 325
22	GAS FIRED HOT WATER BOILER	CRANE-BASMOR GAS-FIRED BOILER-CAT 614C-PG 159-2
23	THERMOSTATICALLY CONTROLLED GAS VALVE	CRANE CO CAT 614C-PG 159-2
24	LIMIT CONTROL	CRANE CO-CAT 614C-PG 159-2
25	DRIP POCKET	CRANE CO Nº 41 CAT Nº 420
26	GAS PRESSURE REGULATOR (DOUBLE INNER VALVE)	FISHER GOVERNOR-FIG 216 VAREC-FIG 186
27	CIRCULATING WATER PUMP	CRANE CO Nº 614 C-CAT PAGE 163-3
28	LOW PRESSURE CHECK VALVE	PFT 4D420-VAREC FIG 211
29	LOW PRESSURE SHUT-OFF WITH MANUAL RESET	FISHER-GOVERNOR-FIG 738

PFT - PACIFIC FLUSH TANK CO
VAREC - VAPOR RECOVERY SYSTEMS CO

NOTES

DRAWING REPRESENTS A SLUDGE GAS-HOT WATER SYSTEM INSTALLATION FOUND IN MANY SEWAGE DISPOSAL PLANTS. A CONSIDERABLE NUMBER OF VARIATIONS AND COMBINATIONS CAN BE USED DEPENDING UPON LOCAL FACTORS.

DRAWING CONFORMS IN ALL RESPECTS TO THE SUGGESTED SPECIFICATIONS COMPILED BY THE NEW JERSEY JOINT COMMITTEE ON GAS HAZARDS OF 1939

——— GAS LINE
— — — WATER LINE

Fig. 1

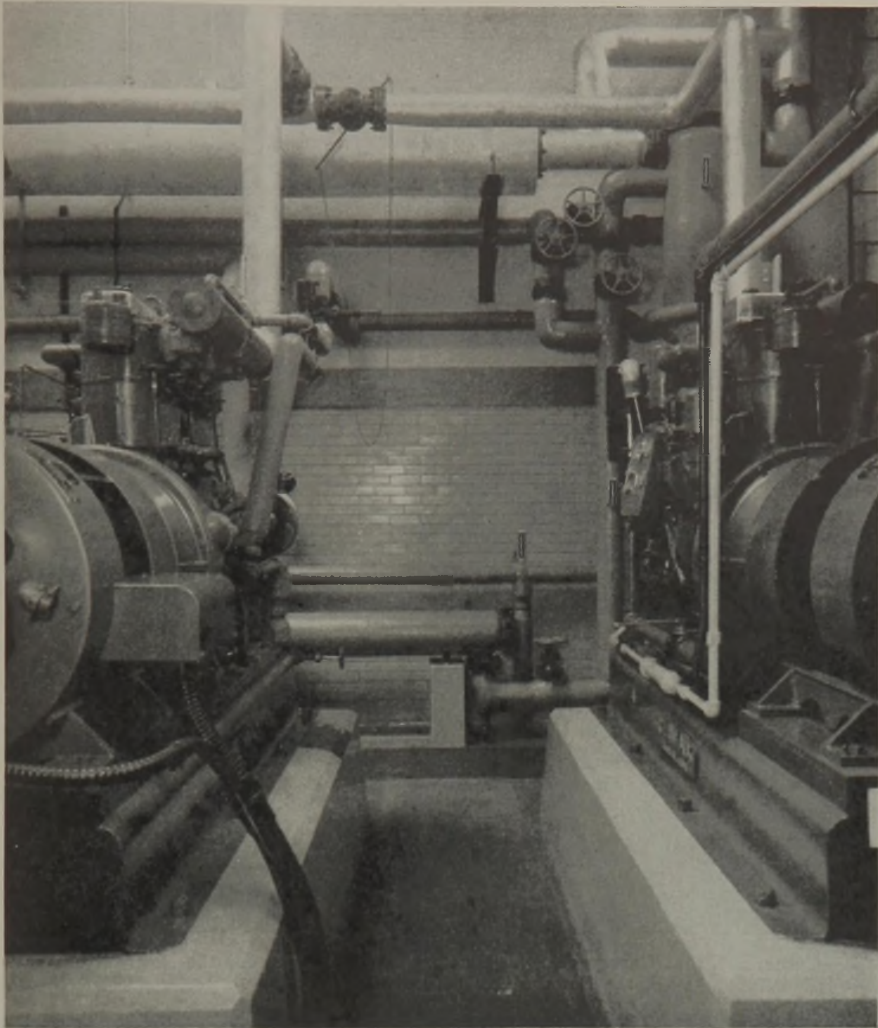


FIG. 2.—Piping Details of Exhaust Gas Heat Exchanger.

been made to present a picture of a typical gas utilization piping system from which the plant superintendent can see what he needs and which he can, in turn, present to the non-technical official who will eventually appropriate the funds.

The water and sewage works section of CRANE CO has been interested in this type of system for some time and has been in a position to cooperate in some research on the materials exposed to sludge gas. Furthermore it has prepared the schematic drawing of a typical utilization system shown below. The research comprises the present experiments being carried on by Mr. W. A. Sperry on the corrosive nature of the sewage gas on the various metals used in the gas utilization equipment. The isometric schematic drawing has been prepared to show the typical piping and equipment arrangement, with an eye to feasibility and clarity and conforms to the best practices of modern gas utilization systems.

The system may be considered as digestion, storage, and service units connected by the necessary piping and appurtenances, and protected by gas control and safety equipment.

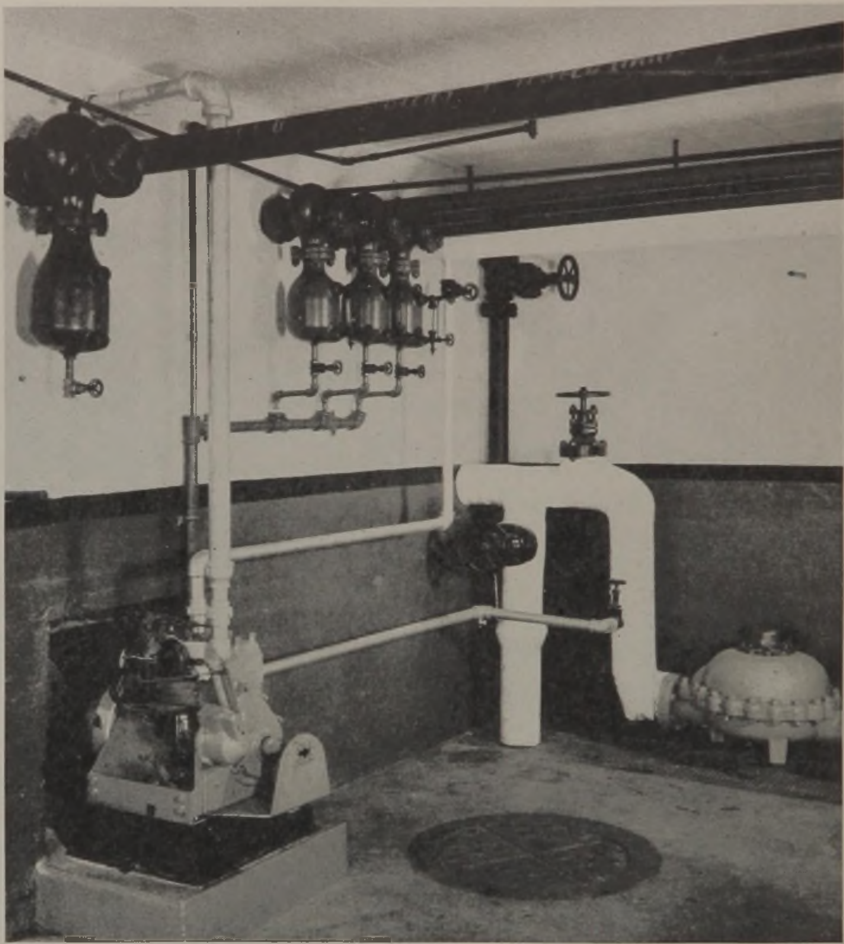


FIG. 3.—Corner in Plant Garage Showing Battery of Separators for the Removal of Water in the Sewage Gas before Metering.

The digestion takes place in a heated tank which has either a rising or a fixed cover, and has heating coils by which a temperature of about 90° F. is maintained in the tank. These coils may be of the horizontal or vertical type. Storage facilities have been a controversial subject, but the conviction seems to fall with the use of some form of gas storage; either the low pressure tank, or the compressor and high pressure tank. Both of these storage systems should float on the line and compensate for the fluctuations in production and consumption of the gas load.

The gas may be utilized in any of the following service units: a gas fired hot water boiler, an incinerator, or a gas engine. The boiler provides hot water for the digester coils or for the house heating system. The incinerator is used to burn the screenings and other potential nuisances about the plant, and utilize the gas as fuel to start the burning. The gas engine, which is by far the greatest consumer of sewage gas, is used to drive the sewage pumps and electric generators. The engine cooling water and hot exhaust gases provide heat for the digester coils. The hot water boiler, however, is used as a standby to function in case of emergency.

The flow of gas and heating water is controlled by valves and fittings, as shown in Figs. 1 and 2 throughout the system. The gas pressure is very low, but the size of the line must be large enough because of the slime-forming characteristics of the gas which in time reduces the area of the pipes. An important factor in maintaining clean pipes and averting eventual trouble in the service units is the separating and draining moisture from the gas. Fig. 3 shows a group of Crane moisture separators on various gas lines at the Aurora Sewage Treatment Plant.

The main function of the gas control and safety equipment is to prevent air from entering the system to form an explosive mixture, and protection against the possible back-firing of the service units.

The relief of the system is the waste gas burner, which burns the excess gas in torchlike fashion outside and away from the buildings. The amount of gas that is burned in the atmosphere is controlled by a waste-gas relief valve which is set to relieve at a couple of inches of water pressure above the regular line pressure.

The material list adjoining the drawing represents an index of the equipment used in a typical sewage gas system.

THE DORR COMPANY, INC.

Engineers

570 Lexington Avenue, New York, New York

RECENT DORR COMPANY DEVELOPMENTS IN THE SEWAGE WORKS FIELD

The last year or so has been a period of intense research and development leading to the successful introduction of several new machines and methods for sewage treatment practice. The major effort has been directed toward improvements designed especially for small and moderately sized communities, as well as army camps, air fields and naval bases.

THE BIOFILTRATION SYSTEM

An Improved Method of Trickling Filter Treatment.—Fifty-six Biofiltration Systems are today in operation or under construction. (Fig. 1.) Never in our

Fig. 1.—Dorr Biofiltration System at Petaluma, Calif. Primary Clarifier and Filter to right of building. Secondary to left and invisible.

experience has any new process aroused such broad interest among members of the profession—been adopted so rapidly by new plants seeking a more efficient method of treatment.

The Biofiltration System gives uniform effluents with fluctuating feeds; permits filter loadings up to 10 times normal with 3 ft. media depths and costs 25 to 50 per cent less to operate than standard trickling filters or the activated sludge process.

The Biofiltration System comprises one or more combinations of a clarifier and a filter wherein unthickened filter discharge is recycled back to the clarifier. Single or multiple stage systems may be employed to give results comparable with chemical precipitation, standard trickling filters or activated sludge process.

This new system is directly applicable to new plants where better than primary treatment effluents are required, or to existing trickling filter or activated sludge plants which are overloaded. Unusual advantages attend its use where industrial wastes are present or where the feed varies widely in volume and composition.

COMBINATION UNITS FOR SMALL PLANTS

The Dorrco Clariflocculator.—The use of chemical reagents to promote the flocculation of fine, slow-settling solids is a well established practice in both sewage and water treatment. It was not, however, until comparatively recently that a research project of ours, conducted both in the laboratory and in the field, showed that simple, mechanical flocculation, without chemicals, had a decidedly beneficial effect on the subsequent settling characteristics of raw sewage and water.

Fig. 2.—Dorrco Clariflocculator at Bakersfield, Calif.

Full scale tests at several field stations checked the research finding. Briefly, it was found that preflocculation of raw sewage, for example, yielded suspended solids removals of the order of 70 to 75 per cent compared with the removals of around 55 per cent generally obtained in primary sedimentation tanks. Likewise, it was found that if the suspended solid removals were held to their normal values, the capacity of a given sedimentation tank could be increased up to 35 per cent if provision was made for preflocculation.

The outcome of these studies was the Dorrco Clariflocculator (Fig. 2)—a combination flocculator and clarifier in a single tank. Compared with a standard clarifier on raw sewage, it gives either up to 23 per cent greater removals of suspended solids or up to 35 per cent greater capacity.

The Dorrco Clariflocculator is installed in a special round tank, divided by a circular baffle into an inner circular compartment and an outer annular one.

Feed enters centrally through an inverted siphon; overflow is taken off peripherally across a continuous circular weir; and settled solids are removed from a central depression in the bottom of the tank.

A special Dorrco flocculator mechanism is installed in the central compartment to promote rapid flocculation of the raw solids to heavy, dense agglomerations having greatly improved settling qualities. Furthermore, a portion of settled floc is subsequently returned to this compartment to provide nuclei for the formation of new floc growths.

The well flocculated solids then pass quietly into the outer annular compartment where continuous sedimentation takes place. Here a Dorr clarifier mechanism is installed to rake the settled flocs to the central discharge opening. A distinctive feature of this unit is the fact that the transfer of floc from the flocculation to the sedimentation compartment is so gentle that the flocs are not disintegrated or their settling qualities impaired.

A two-speed drive head is employed in order to provide different speeds to the two vertical shafts, concentrically arranged, one with the other. The outer tubular shaft is driven at a relatively higher speed than the inner solid shaft, and is connected to the moving elements of the Dorrco flocculator. The inner, slower shaft is connected to the Dorr clarifier mechanism directly below.

The moving elements of the Dorrco flocculator are a series of rotating, wedge-shaped, vertical paddles. In their travel they intermesh repeatedly with corresponding fixed, vertical paddles suspended from the transverse beams. The net effect is a gently controlled agitation in the flocculation zone—somewhat similar to a series of "barrel rolls"—that gives the raw solids the maximum opportunity to impringe upon one another and grow to heavy, dense floc formations.

The Dorr Clarigester.—From a processing standpoint the Dorr Clarigester is a simple, self-contained separate sludge digestion plant in a single compact unit. The upper compartment, in which sedimentation takes place, is essentially a Dorr clarifier. Just as in a Dorr clarifier, feed enters centrally, overflow is collected peripherally and settled solids and scum are collected and disposed of mechanically. Likewise the lower compartment, where digestion is carried out, is a direct counterpart of a Dorr digester. Sludge is stirred mechanically and mechanical means are employed for destroying floating scum. Gas is collected and led to gas lines for utilization and heating coils are installed for temperature control.

Mechanically, the Dorr Clarigester is a circular, two-story tank, equipped with a Dorr clarifier mechanism in the upper or sedimentation compartment and a Dorr digester mechanism in the lower or digestion compartment. Feed enters the upper sedimentation compartment through a radial influent pipe terminating in a central, semi-submerged, cylindrical feed well. From this point flow takes place throughout this compartment along radial diverging lines, finally reaching its lowest velocity close to the periphery where it overflows across a continuous circular weir.

A vertical shaft, driven by a gear motor and supported on transverse steel beams, carries both the clarifier and digester mechanisms. The clarifier mechanism consists of two radial arms, to which plow blades are attached. These blades sweep the upper surface of a dish-shaped diaphragm or tray that divides the tank into two compartments. Suspended solids settle upon this tray or floor and are raked gently to the center bottom of the sedimentation compartment. At this point they are collected in a hopper and dropped through a seal into the lower or digestion compartment.

The digestion compartment is provided with a mechanism that both stirs the settled sludge to promote rapid digestion and gasification and also breaks up the scum that forms on the under side of the tray. The sludge-stirring mechanism consists of two rake arms with plow blades that just clear the bottom of the tank. The revolving scum breaking mechanism is just below the tray and is composed of two radial arms, provided with vertical, upcast fingers that intermesh with corresponding stationary downcast fingers, on the bottom or underside of the tray.

A gas duct is provided at one point in the side of the tank to conduct the gas formed just below the tray to a gas dome and thence to the gas pipe. Heating coils extend around the inside of the digestion compartment and water, heated by sewage gas, is circulated through these coils to maintain the optimum temperature for digestion. A scum drain is placed at the upper end of the gas duct in case any scum should rise to this point.

A draw-off connection in a hopper in the bottom of the tank leads to sludge drying beds or other means of disposal. A trap in the tray effectively prevents the passage upward of liquid or gas from the bottom to the upper compartment.

The Currie Claraetor.—The Currie Claraetor, a combination unit providing clarification and aeration in a single tank, brings the activated sludge process within the means of small municipalities with populations ranging from 5,000 to 15,000 and upwards.

The Currie Claraetor consists essentially of a circular tank, divided by an inner concentric ring into two separate compartments. One of these, the aeration compartment, is annular in shape and lies between the outer tank wall and the inner, concentric ring. The other, the centrally located clarification compartment, is circular or square, and is similar in general to the conventional tank used with Dorr clarifiers. Activated sludge is withdrawn from the sedimentation compartment by a Barnes-Dorrco sludge pump or a Dorrco diaphragm pump.

An ingenious system of channels and stop gates permits the influent to be passed through any combination of chambers in series. Thus any chamber or combination of chambers may be temporarily withdrawn from service without interrupting operation. All the aeration chambers may be taken out of service, if desired, and the influent by-passed directly to the clarification compartment.

The Currie Claraetor takes its name from its inventor, F. S. Currie of San Bernandino, Calif.

NEW DORR CLARIFIER SHAPES

Square and Rectangular.—While the preferred shape of Dorr clarifiers is still round, two different shapes are now offered to meet certain conditions. These two new types are described below:

The Dorrco Squarex Clarifier.—Dorrco Squarex clarifiers, for installation in square sedimentation tanks are of two types—the central, siphon feed type with peripheral overflow and the side feed, side overflow type with flow taking place across the tank in a diametrical direction.

The siphon feed type of Dorrco Squarex clarifier (Fig. 3) follows closely the arrangement of the Dorr Sifeed clarifier with the exception that the tank is square, not round, and one of the rigid arms of the clarifier mechanism is equipped with a special corner blade that reaches out into the four corners of the tank and moves the settled sludge in to the point where it may be picked up by the regular mechanism.

The distinctive feature of the Dorrco Squarex clarifier is the positive means provided for sweeping the area of the tank bottom comprised within the corners of the tank and lying beyond the reach of the regular rake arms. The blade that performs this operation is positive in its action, yet so simple in design that there is practically no possibility of its getting out of order.

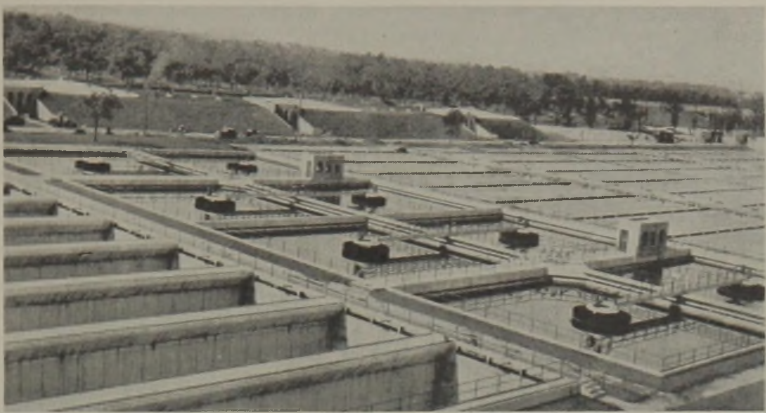


Fig. 3.—8 Dorrco Squarex Clarifiers at Gary, Ind. Activated Sludge Plant. Note 3 Dorr Multdigestion Systems in background.

The side feed type of Dorrco Squarex clarifier is identical mechanically with the siphon feed type described above. Feed enters through submerged ports or across a weir at one side of the tank. Overflow is taken off across a weir extending along the entire side of the tank opposite to the point of feed inlet.

Since there is no central siphon feed, the center column supporting the mechanism and drive unit is solid.

THE DORRCO MONORAKE

The Dorrco Monorake was developed primarily to meet the need for a mechanism that could be installed in existing, rectangular sedimentation basins, for continuous clarification and the mechanical removal of sludge. Two types are available, one for open and the other for covered tanks.

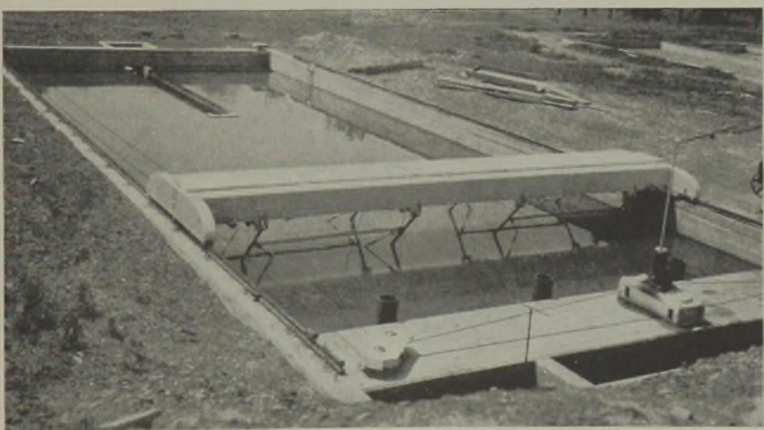


Fig. 4.—Dorrco Monorake at Conway, Arkansas.

The Dorrco Monorake may be installed in open or covered rectangular tanks of any length, with widths up to 75 ft. The rake supporting carriage rides on longitudinal rails. Carriage and rails may be either above or below the liquid level, depending upon the type of tank construction.

Balanced rake mechanisms are supported and operated from the traveling carriage in such a manner that they are alternately in the raking and idling positions. The rakes are down in the raking position when the travel is toward the sludge hoppers. As the mechanism travels away from the sludge hoppers, the rakes are in the idling position so that settled sludge will not be disturbed.

In Monorakes constructed for open tank installations with the carriage above the liquid surface, anti-friction bearings are used. In those models designed for installation in covered tanks with the carriage below water, the bearings are of water-lubricated, phenol-impregnated fibre.

Stainless steel traction cable is used. The drive unit in all cases is a stationary motor, direct-connected to a speed reducer, all mounted on the top of the tank.

A VARIABLE RATE SLUDGE PUMP

This pump, as its name implies, is of the two chamber V-type and in appearance slightly resembles an inverted V-type automotive engine. The twin pumping chambers are meehanite castings and are each provided with individual suction and discharge valves, rubber diaphragms and plunger rods.

The valves are of the ball type, constructed of lead-impregnated rubber, seating upon removable hard rubber rings. Balls and seats of other material can be furnished. Hand holes are provided for ready inspection. The rubber diaphragms are of cord construction, with headed edges and arranged for quick, easy replacement.

The twin plunger rods are removed directly up and down at right angles to the normal planes of the diaphragms by a rocking member. This rocking member is driven by a connecting rod that terminates in a crank on a horizontal counter shaft.

A distinctive feature of this new pump is the fact that the stroke of the plunger rod and hence the rate of discharge may be changed at will while the pump is in operation. Thus the stroke of the plungers may be varied from a minimum of ⅝ in. to a maximum of 3 in., corresponding to a 5-to-1 variation in rate of discharge. A stroke indicator dial and a pointer are provided, calibrated from 0 to 3 inches in quarter-inch intervals.

The pump is driven by a standard motor, connected to a counter shaft by V-belts and thence to the horizontal crank shaft by helical gear and pinion. All speed reduction is effected by the V-belt sheaves and gear train, thus permitting the use of a standard motor rather than one of the more expensive gear type.

HIGH RATE DORRCO DISTRIBUTOR OF DOUBLE-DECK ARM CONSTRUCTION

To take care of the high rates of sewage application on trickling filter beds, we have developed special types of two-arm and four-arm distributors to operate at relatively low head. Characteristic features of these units are the use of tapered arms having a box section with rounded corners and terminating in a true circular section at the end of the arms.

Single compartment arms may be used where the head available is in excess of that required at maximum flow at a definite setting of the orifices or slots. When the flow fluctuations are considerable (3:1), and it is desired to operate at low head, the arms have two compartments, one above the other, to take care of this condition. The bottom compartments are designed to handle any desired proportion of the maximum design flow, quantities in excess of this being taken by the top compartments.

Both types of units may be designed to operate at heads in the center column as low as 18 in. to 24 in. above the stone surface. In single compartment units adjustable rectangular slotted openings are along the side of the arms near the bottom. In the case of two compartment arms, the openings are near the juncture of the compartments.

A continuous spreader is located below the openings so that a continuous sheet of liquid is laid on the surface of the filter as the arms rotate. The height of the slots is so regulated that the average speed of the four arm unit does not exceed 1.5 r.p.m., or the two-arm machine 3.0 r.p.m. Because of their lower cost the two-arm units are preferred and should be used wherever practicable.

DRESSER MANUFACTURING COMPANY

Bradford, Pennsylvania

PIPE COUPLINGS AND FITTINGS, REPAIR CLAMPS AND SLEEVES

One of the most significant developments in the joining of cast-iron pipe in the sewage field is the new Dresser Bellmaster Joint—a single-gasketed, self-contained mechanical joint that is strong, flexible, corrosion-proof.

The Bellmaster Joint consists of a few simple parts—inner ring, armored gasket, outer ring, a set of capscrews—all factory assembled into a single unit

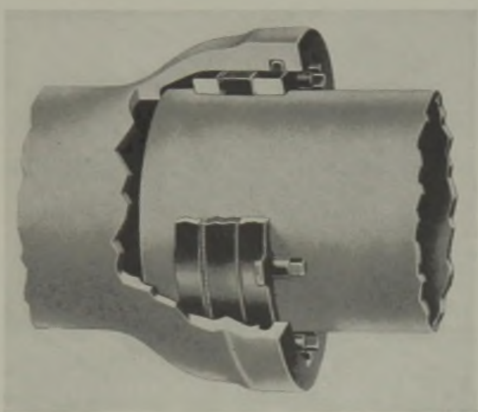


Fig. 1.—Cutaway view of Dresser Bellmaster Joint, Style 85.

(Fig. 1). To install, the Bellmaster is simply inserted in the bell end of pipe prepared to accommodate the Joint, locked in place by twisting slightly clockwise, spigot end "stabbed in," and capscrews tightened. Working principle is simple and effective: as you tighten the capscrews, the inner ring is drawn closer to the locked outer ring, thus expanding the gasket against the outside of the spigot and against the inside of the bell, making a tight seal against both.

Time studies in all sorts of weather and ditch conditions prove that an ordinary workman can install a Bellmaster Joint in from 2 to 5 minutes. All that is needed is a small ratchet wrench. Whether laid on top, side, or bottom of ditch, cast-iron pipe joined with Bellmasters can be laid in less time than with other jointing methods.

This "floating joint," with its large-section resilient gasket, allows deflection in any direction, as well as longitudinal movement caused by expansion and contraction. Its unusual deflective properties permit connecting pipe over a ditch and "snaking" it in even when rounding a curve. In the smaller sizes, it can be deflected through an arc of as much as 18° without impairing its tightness or efficiency.

The Bellmaster is completely enclosed by the bell of the pipe in which it is inserted. There are no exposed parts or outside lugs. Possibility of capscrews in joints being broken due to settlement of line is eliminated because capscrews, as well as entire joint, are independent of the bell or spigot; stresses in screws remain constant regardless of degree of deflection in the joint.

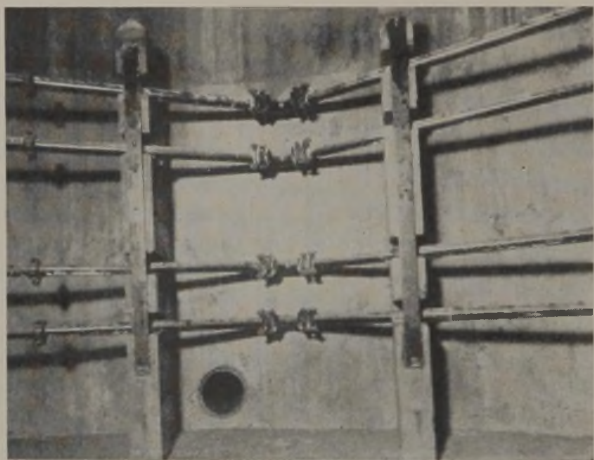


Fig. 2.—Heating coils in sludge digestion tank at Troy, Ohio. Dresser Couplings simplify construction of piping system.

Leading cast-iron pipe manufacturers can furnish pipe with bell ends suitable for Bellmaster Joints. The Style 85 Bellmaster is at present available in the following CIP sizes—4 in., 6 in., 8 in., 10 in., 12 in., and 16 in. Other sizes will be available soon.

Also playing an important part in the sewage systems of many municipalities are Dresser couplings and fittings for steel pipe. With a record of a half-century of service in many fields, Dresser couplings are used extensively in joining intercepting sewers, pressure sewers, inverted siphons, outfall sewers, etc. Dresser fittings are employed in joining small pipe in sewage-treatment plants, sludge lines, heating coils, water lines, etc. A few recent installations are illustrated below.

At Troy, Ohio, heating coils connected with 2 in. ID Style 38 couplings (Fig. 2) warm sludge in a digestion tank at the new sewage-treatment plant. Dresser couplings eliminated threading and made joining of plain-end pipe simple and speedy.

At Brighton, N. Y., a 200-ft. outfall sewer carries sewage across a ravine

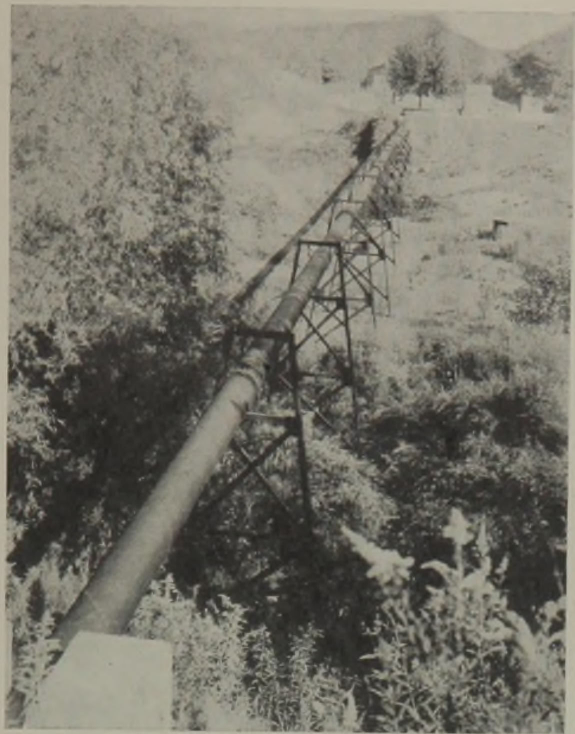


FIG. 3.—Outball sewer at Brighton, N. Y. 13 inch steel line joined with Dresser couplings.

from South District No. 4 and north part of District No. 2 to sewage-disposal plant of Sewage District No. 2. 13 in. OD steel line is joined with Dresser Style 38 couplings.

FILTRATION EQUIPMENT CORPORATION

10 East 40th Street, New York, N. Y.

THE AUTOMATIC MAGNETITE FILTER
RECENT TRENDS IN DESIGN AND DEVELOPMENTS

The magnetite filter, for the past ten years, has been in the process of progressive technical development relative to its use and application as well as from the standpoint of design. Two upflow filters on the inside periphery of circular settling tanks at Dearborn, Michigan, for straining chemically treated effluent mark the the first practical application of this equipment. The chain of developments leading up to the present design is undoubtedly typical of the engineering progress in other types of sewage treatment equipment and therefore merits brief review as a matter of interest.

The use of upflow filters for straining plain settled, trickling filter and activated sludge effluents followed the Dearborn installation. Limitations in filter rates at peak solids and peak flow conditions, and choking of the screen led to modifications in design of the magnetite filter from upflow to downflow filtering which has now been adopted exclusively for new installations.

Downflow filters were first built in long rectanglar separate structures.

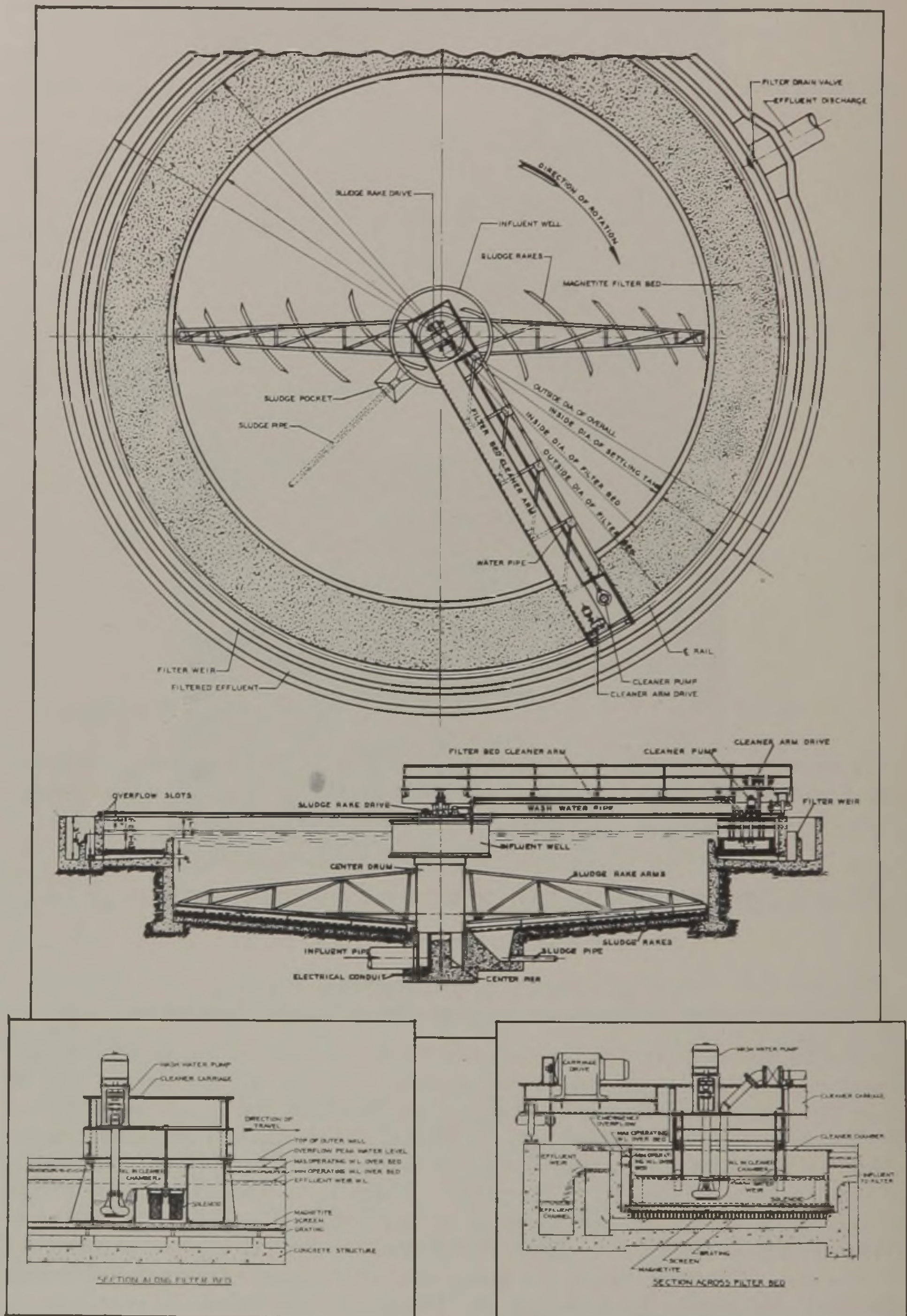


FIG. 1.—Magnetite filter installation.

Considerable difficulty was encountered in obtaining proper distribution of flow so as not to disturb the magnetite. This was overcome, partially by improving hydraulic design of influent ports and adjoining channels, and partially by automatic scrapers to provide a slight correction to any magnetite which became dislodged.

Recently installed magnetite filters of the circular downflow type, have been free from problems of hydraulic distribution or shifting of magnetite. In these units the filter bed behind the cleaner acts as a distribution channel, consequently velocities are low and do not set up currents to disturb the filter media. Another advantageous feature of this design is the fact that the cleaner does not reverse itself and travel over a portion of the bed just cleaned as in the case of the rectangular units.

One of the distinguishing features of the newly developed downflow magnetite filter is the so-called 3-level arrangement whereby the liquid in the cleaner box is lower than the effluent weir so as to provide a backhead in the cleaning

FIG. 2.—Woodbridge, N. J. Downflow magnetite filter in annular ring separate structure for straining plain settled effluent.

chamber. This feature eliminates pollution of the effluent during cleaning. It is accomplished by completely sealing the cleaning chamber against the hydraulic head over the filter bed. It is possible to seal the cleaning chamber effectively even when the friction loss through the bed is as much as ten inches.

It was demonstrated by parallel tests in box filters that 3 inches of fine magnetite was more effective in obtaining better removals of suspended solids than by deeper beds of coarser media. As a result of these findings, the trend has been toward the use of finer magnetite rather than to deeper beds to meet the ever increasing demand for clearer effluents. Due to limitations of screen openings finer magnetite was not possible with upflow filters. Magnetite even as fine as 0.40 mm. (30 to 60 mesh) average size is in successful operation in the downflow filters.

One of the most recent adaptations has been for removing oil, suspended solids and turbidity from oil field and refinery wastes. The wastes are dosed with alum, flocculated with mechanical paddles in a circular tank and applied directly to the magnetite filter without intermediate settling. Well clarified effluents, free from oil, are obtained with relatively low dosages of alum. The magnetite filter is built around the flocculator and the flocculated effluent flows over a wall on to the filter. Filter wash water is settled in a separate wash water concentration tank.

Final effluents containing 5 p.p.m. suspended solids on bio-filtration and activated sludge have resulted from the recent downflow magnetite filters. By the use of the finer grades of filter media and filtration rates of about 2 to 3 gallons per sq. ft. per min., magnetite filters may be designed to produce final effluents to contain about 25 p.p.m. suspended solids when treating plain settled effluent and under 15 p.p.m. when operating on adequately chemically precipitated and settled effluent.

Plain settled effluents at peak filter rates of 6 gal. per sq. ft. per min. have been filtered through coarse magnetite, and the filters have remained operative with as much as 200 p.p.m. suspended solids applied at filtering rates of approximately 3 gal. per sq. ft. per min. Filtered effluents under such extreme conditions have contained averages of 50 p.p.m. with maximum of 100 p.p.m. suspended solids.

The magnetite filter is now at a stage of development where it provides another step in any method of removing fine suspended solids from liquids whether the liquid to be clarified is domestic sewage effluent, industrial water

FIG. 3.—Liberty, N. Y. Downflow magnetite filter surrounding chlorination contact chamber for straining settled 2-stage bio-filtration effluent.

supply, trade waste or industrial process liquor. It is economically adapted to straining out light solids and minute impurities which cannot be readily segregated from the various liquors by sedimentation.

The automatic magnetite filter may take various convenient forms to facilitate installation in combination with other processing steps such as settling tanks, flocculators, chlorination contact chambers, clear wells or in separate structures.

Designs are quite flexible in adaptation and use ranging from coarse grained filters at high rates of operation and filtering liquors containing large amounts of suspended solids to fine grained filters for producing extremely polished effluents. In each case the design is governed by the length of filter bed which can be adequately cleaned before the solids reaching the filter cause the loss of head to exceed the allowable limit of practical cleaning operation.

FISHER SCIENTIFIC COMPANY

711–723 Forbes St., Pittsburgh, Pa.

EIMER & AMEND

205–223 Third Ave., New York, N. Y.

NEW LABORATORY APPLIANCES
SYNTHETIC DAYLIGHT FOR TITRATIONS

Three times as much light for the same current consumption; light of a better quality; a lamp that stays cool and casts practically no shadows—these are the reasons why the new fluorescent lamps are replacing incandescent lamps in so many up-to-date laboratories.

The fluorescent lamp has now been adapted to another laboratory use—that of illuminating areas in which titration and other color reactions are being conducted.

The Fisher Fluorescent Titration Illuminator is an attractive metal unit about 19 inches wide, seven inches deep and 13 inches high. The outer surfaces are aluminum crackle while the reflecting surfaces are finished in satin aluminum that diffuses the light evenly. The lamp is attached at the center of a semicircular reflector so that its rays are directed by the slanted surface to the area where light is needed.

The Fisher Fluorescent Titration Illuminator has a convenient "on-off" switch and is supplied with cord and plug for use with 110 volts A.C. only, for $12.50. It consumes only 15 watts.

An ideal assembly for titrations is this new illuminator with the Fisher support stand. The stand consists of a substantial porcelain base with 23″ anodized aluminum rod, and a Castaloy double burette holder. The stand with holder is available for $5.00.

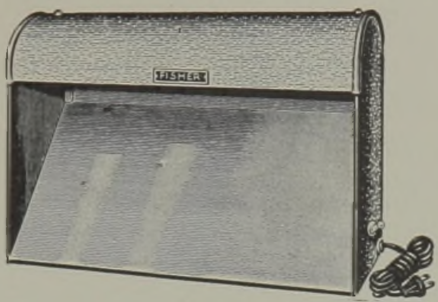


FIG. 1.—The Fisher Fluorescent Titration Illuminator provides cool, dispersed, artificial daylight that enables more accurate color discriminations.

ANOTHER FLUORESCENT LAMP

About a year ago the Fisher Universal Fluorescent Lamp was introduced for use in illuminating the interior of balance cases, spot plates, apparatus assemblies and for other similar uses. Its ready acceptance by laboratorians hastened the designing of the new Titration Illuminator. These two lamps enable the laboratorian to make color discriminations with the same degree of accuracy that would be possible by working in daylight.

The Fisher Universal Fluorescent Illuminator can be had for $12.00. Its tube is mounted in an adjustable, highly polished reflector that will rest on a balance case. An arm is attached to the reflector housing to facilitate fastening the illuminator to supports or Flexaframes.

LIGHT WEIGHT GLOVES NOW MADE OF NEOPRENE

Neoprene gloves are being worn by an increasingly large number of laboratorians now that it has been proved that the longer service they provide more than justifies their slightly higher cost as compared with rubber gloves. The demand for a light weight glove of this material has resulted in the addition of such a product to the list of Neoprene items available to laboratorians.

The new light weight gloves are more satisfactory because they fit the hand better and permit more freedom in handling objects while working with materials that attack rubber. Neoprene, as is well-known, resists attack by such liquids as gasoline and other petroleum products as well as many acids and alkalies that rapidly damage natural rubber gloves. It has also been found that Neoprene does not cause harmful effects that sometimes result among those who are allergic to contact with rubber.

These gloves are black on the outside and red on the inside for quick identification and so the wearer will not attempt to put them on "wrong side out." They withstand sterilization and are sufficiently heavy for many laboratory uses.

Three sizes of these Neoprene light weight gloves, 7, 8 and 9, are available at $.75 per pair. A discount of 10 per cent is made for purchases in lots of 12 pairs.

When more durable Neoprene gloves are required, the Neoprene heavy weight gloves are suitable. They are available in sizes 8 and 9 at 1.25 and size 10 at $1.35 per pair or at a discount of 10 per cent in lots of 12 pairs. This cost, a reduction of 25 cents from the former price, has been made possible by the increased demand for Neoprene gloves.

THE FOXBORO COMPANY

Foxboro, Massachusetts, U. S. A.

FOXBORO INSTRUUMENTS FOR SEWAGE TREATMENT METHODS

The instruments for sewage treatment applications offered by The Foxboro Company, Foxboro, Mass., now include a complete line of float-and-cable operated equipment for flow and liquid level measurement, telemetering, and control, with either pneumatic or electric operation. Typical of these is the flow meter

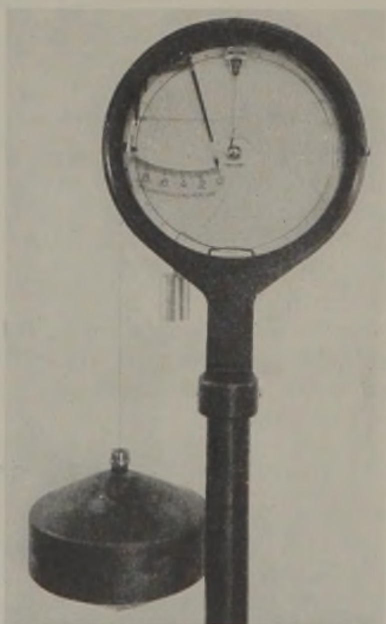


Fig. 1.—This Recording and Integrating Flow Meter is representative of The Foxboro Company's new line of float-and-cable operated instruments for sewage and water works applications of measurement and control.

(Fig. 1). This meter has a new and simplified cam mechanism, designed for use with the integrating and recording units which are standard in other Foxboro instruments.

Standard models are available for V-notch, rectangular, or Sutro weirs and Parshall flumes, with uniformly graduated charts, and with indicating scales reading directly in flow units, and with direct-reading integrator with speedometer type counter.

Complete overrange protection is built in on the cable drum and instrument cam. There is a large external micrometer for easy and precise zeroing of the instrument in the field.

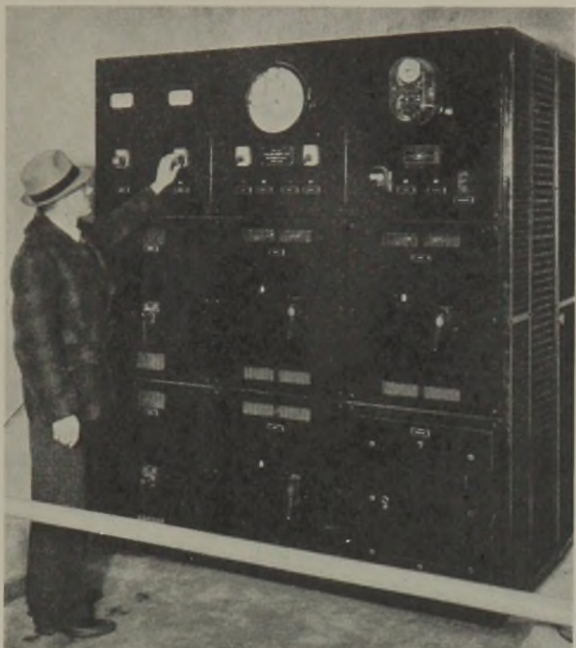


Fig. 2.—Automatic control instrumentation in an unattended pumping station. The Foxboro Recording Liquid Level Controller (top center) automatically cuts in, successively, two pumps on increasing wet well level, and cuts both pumps out at a single low level. Automatic sequence changing is provided for the main and booster pumps, and in addition, adjustable high and low level signals warn of any equipment or power failure.

In the liquid level measuring instruments, the movement of the cable drum is transmitted to the pen mechanism through a precision gear train equipped with anti-backlash gears. Standard ranges are from 0 to 5 and 0 to 30 feet. The same cable and drum mechanism used on these instruments has been used with suitable weighted floats to measure sand level in filters or launders, and to measure gas holder position, hydraulic ram position, and level of slurry and other semi-fluid solids.

Multi-pen recorders, including one float-and-cable operated measuring system, with other measuring systems for temperature, pressure, liquid level, or flow, are all available through the combination of standard Foxboro instrument units. For example, wet well level and the operation of several pumps can all be recorded on a single chart.

Instruments for either flow or liquid level measurement can be also combined with any of the standard Foxboro air-operated control mechanisms; or for pumping control, float-and-cable operated instruments are also available with Rotax electric-operated systems. Fig. 2 illustrates an unattended pumping control installation of this type. A Foxboro recording controller automatically cuts in successively two pumps on increasing wet well level, and cuts both pumps out at a single low level. Automatic sequence changing is provided for the main and booster pumps, and in addition adjustable high and low level signals, operating from a separate battery circuit, warn of any equipment or power failure.

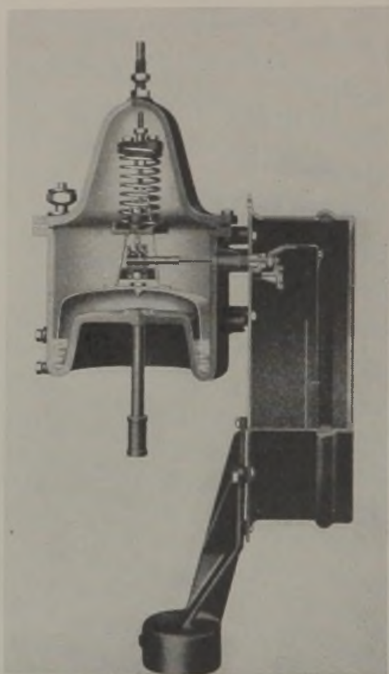


FIG. 3.—The simple operating principle of the Foxboro Bell-Type Meter is shown in this cut-away view. Differential pressure across an orifice in the gas line is measured by the vertical movement of the bell, mercury-sealed at the bottom of the chamber and opposed by a calibrated spring at the top. Its movement is translated directly into movement of the recording pen, by a unique friction-free shaft and pressure-tight bearing.

Another development of interest to sewage works engineers and operators is the application of Foxboro Bell-Type Flow Recorders on sludge digester gas lines, to measure the rates of flow and total quantities of gas generated, gas to hot water boilers and to engines, and gas to waste burners. These instruments measure the rate of gas flow by measuring differential pressure across an orifice placed in the gas line. Through a long program of research and experiment by the American Gas Association and by the Bureau of Standards, coefficients for this type of measurement have been determined with accuracies equal to those for Venturi tubes.

The simple construction of the differential pressure measuring mechanism in this instrument is shown in Fig. 3. The pressure from the two orifice taps are applied to the top and bottom sides of the inverted bell, which is sealed in mercury. Vertical motion of the bell is opposed by the large, calibrated coil spring.

The position of the bell is thus a direct measurement of differential between the two pressures and is used to operate the recording and integrating mechanisms.

The few parts of this measuring system change position only when, and as much as, differential pressure changes, and are not in continuous motion. The resulting advantages in easy, trouble-free service are obvious. In addition, all parts are metal, and there are no periodic part replacements to make.

Another feature of the design of this instrument, contributing to its long and trouble-free life, is that the sewage gas does not pass through it, as in meters of most other types. The two connections from the orifice fitting to the meter transmit static pressure only. Furthermore, all parts of the meter which actually are in contact with the smaller amount of gas that does enter the meter are of highly corrosion-resistant metals.

The pressure loss caused by this equipment is ordinarily about ½ in. of water, which compares favorably with other types of meters. If necessary, even this small loss can be reduced.

A continuous chart record of the rate of gas generation in the digester is a valuable aid for the use of the plant operators, supplementing the data supplied by such routine and periodic tests as sludge pH, sludge index, digester temperatures and various measurements of levels and volumes. Also, the total flow of gas is continuously integrated by the meter, and the total can be read directly, on a speedometer-type counter.

The great flexibility of this meter is one of its conspicuous advantages. A single indicating, recording and integrating instrument costs but little more than a single displacement-type meter, yet can replace a whole battery of such meters. When rates of gas generation change, Foxboro meter capacity can be changed by merely changing the orifice in the gas line. The orifice flange union can be installed at any convenient point in the line, and the connecting pressures lines are run from this flange to the instrument; thus it is possible to locate the meter wherever it is of greatest convenience to the operators, regardless of the point at which measurement is taken. A final advantage to be mentioned is that the Foxboro Bell-Type Meter occupies much less space than any other metering equipment of similar capacity.

GRUENDLER CRUSHER AND PULVERIZER COMPANY

2900 N. Market St., St. Louis, Mo.

EFFICIENTLY OPERATED SEWAGE PLANTS HAVE INSTALLED SHREDDERS FOR COMPLETE SEWAGE AND GARBAGE DISPOSAL

Sewage and garbage shredders, engineered and built by the Gruendler Crusher and Pulverizer Company of St. Louis, have been selected by sanitary engineers for installation in sewage plants of numerous American cities including Atlanta, Ga., Appleton, Wis., Chicago, Ill., Coney Island, N. Y., Dallas, Texas, Rock Island, Ill., Rutherford, N. J. Selected also by the U. S. Navy to provide necessary sanitation on the newest model ships now in construction.

The Gruendler Shredder with its patented features such as the *Non Clogging Grip Bars, Safety Tramp Iron Catchers,* and *Improved Water Spray Flushers,* has been observed and welcomed by sanitary engineers as the answer to uninterrupted and continuous flow and proper disposal of sewage and garbage, eliminating the nuisance of undesirable products, such as garbage, leaves, sticks and fre-

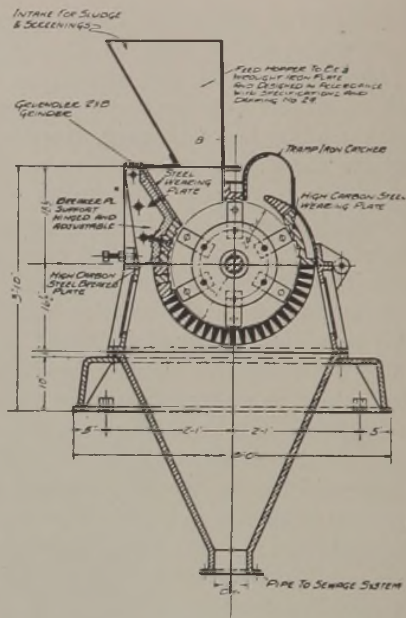
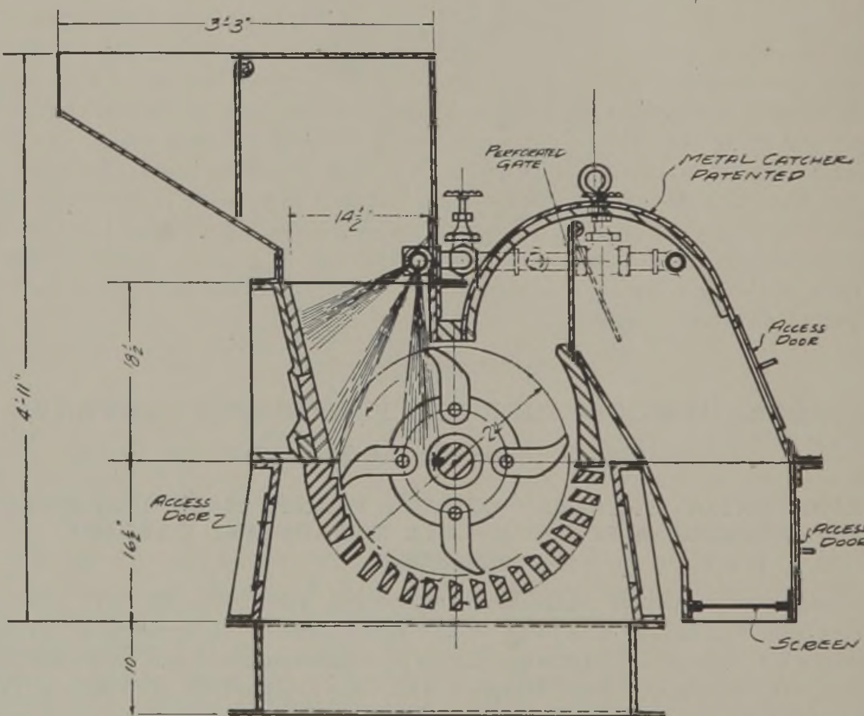


Fig. 371-58 (to right) — Gruendler Sludge and Screenings Grinder.

Fig. 371-59 (below)—Special design Gruendler Garbage Shredder.



quent quantities of prevailing rag stock. Clogging of valves and sewage lines has been an outstanding reason for the acceptance of the Gruendler Sewage Screening Shredder. The Gruendler Garbage Shredder makes an ideal connection with an incinerator—it grinds, mixes and prepares product for most efficient combustion and proper feeding.

Gruendler Shredders are dependable and of sturdy construction with sealed bearings to withstand continuous operation. The safety feature of the Gruendler

Tramp Iron Catcher is note worthy, since foreign matter such as cans or metal, which is ungrindable, is easily removed through "Access Door" provided. These shredders are built in many sizes and can be fitted in most difficult plant arrangements, taking a minimum of space. The grinding of sludge to uniform sizes for commercial fertilizer is another operation performed by Gruendler Shredders.

Blue prints and sewage plant layouts together with specifications will be gladly furnished by the Grundler Company. Address Plant and General Offices in St. Louis, Mo.

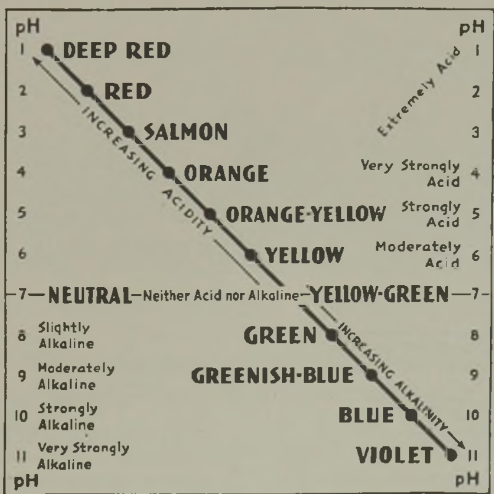
HELLIGE, INC.

SCIENTIFIC INSTRUMENTS—LABORATORY & BACTERIOLOGICAL SUPPLIES

3718 Northern Blvd., Long Island City, N. Y.

DETERMINING THE HYDROGEN ION CONCENTRATION WITH HELLIGE COMPARATORS

Determination of the Indicator to be used. If the approximate pH value of a test solution is not known, the first procedure to be undertaken is to determine whether the solution is acid, neutral, or alkaline. This can be conveniently done by using an indicator such as Bromthymol Blue (pH range 6.0 to 7.6), which gives a definite color change in a slightly acid or slightly alkaline solution. However, since the chances are that the test solution is more acid or more alkaline than can be determined with this indicator (the indicator reacts yellow on all solutions below pH 6.0 and blue on all solutions above pH 7.6), the test would have to be repeated with other indicators, usually of limited ranges, until the proper one is found.



This inconvenience is overcome and considerable time can be saved by employing the Hellige Wide Range Indicator for the primary test, since this indicator covers a pH range from 1 to 11 and shows within this range all the characteristic shades of the spectrum. Comparison of the color of the test solution, after the Hellige Wide Range Indicator has been added, can either be done with a color disc for this indicator which covers an extended pH range, or with a color chart. Bottles containing the Hellige Wide Range Indicator are also supplied with a color scale label, if desired and so specified, at an additional cost of 50 cents.

Without the aid of a color disc or a color chart an approximate determination can also be made by using the following table, which shows the color shades of the indicator for definite pH values.

If using a disc of color standards for the Hellige Wide Range Indicator, it is recommended that the correct ratio of test solution and indicator be adhered to (10 ml. test solution + 1 ml. indicator solution—or similar ratio), as this enables one to make the final accurate determination with the same mixture by a comparison with glass standards.

INTERNATIONAL FILTER CO.

325 West 25th Place, Chicago, Ill.

NEW CIRCULAR CLARIFIER AND SKIMMER

In the process of sedimentation it is extremely important that optimum quiescent conditions be maintained. The new Infilco PD peripheral drive clarifier with its geometrically curved scraper blades and anti-friction bearings assures the smooth operation necessary to secure this quiescence.

The PD clarifier mechanism (Fig. 1) is designed for operation in a circular sedimentation tank with a central inlet through the bottom of the tank and a

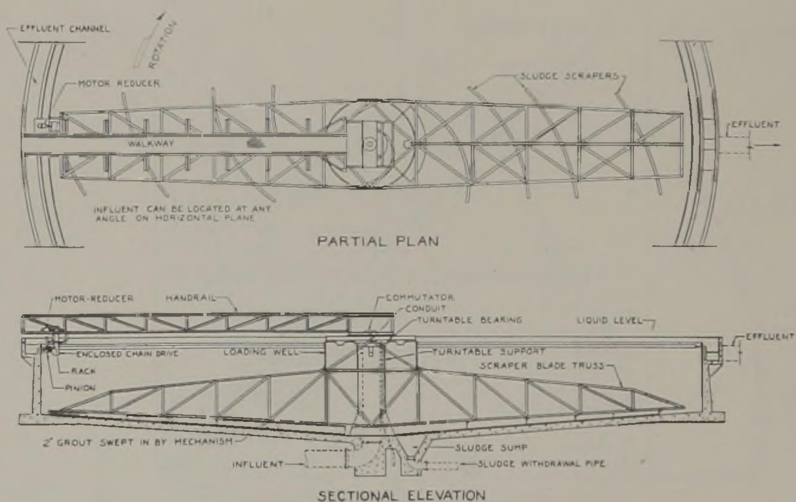


Fig. 1.—Plan and Elevation of the PD Clarifier.

peripheral overflow weir. Sludge scraper blades sweep solids settled to the bottom of the tank to a sludge sump located near the center of the tank. The entire sludge scraper assembly rotates on a central supporting member surrounding the inlet pipe or conduit. The assembly is rotated from the tank periphery through a bridge structure.

The scraper blades supported by structural truss members, are so formed that a tangent to the blade curve at any point makes a constant angle with a radius vector at that point, thus moving settled solids toward the sludge sump with the least possible disturbance. The scraper blade assembly is rotated at a speed that will insure a particle deposited at the outer periphery of the basin being moved to the sludge sump within a time interval approximating the design detention period of the basin. Prolonged anaerobic storage of settled solids with the attendant possibility of septic action and excessive surface scum formation is thus avoided. Each scraper blade includes a stiffener which forms a right angle with the blade providing rigidity to the scraper blade as well as to the supporting truss at each blade position. The lower edge of each blade is equipped with an adjustable bronze squeegee which assures proper clearance above the tank bottom for effective removal of settled solids.

The sludge scraper assembly is supported by a vertical stationary column or tower by means of a turntable bearing. Alignment rollers keep the rotating assembly properly centered. The bridge structure, in addition to acting as a structural drive arm to rotate the scraper assembly, includes a walkway providing access to a commutator and the turntable bearing with the alignment rollers located at the tank center. The upper chords of the bridge structure serve as hand rails.

Fig. 2.—Two Primary PD Clarifiers at Fort McLellan, Anniston, Alabama.

Attached to the sludge scraper assembly so as to surround the central turntable supports is an influent loading well which assures uniform vertical flow and radial flow distribution.

All structural shapes for the scraper truss assembly and the bridge truss are selected not only to permit minimum deflection for the loads imposed, but also to insure a durable mechanism. All structural members are of ample size to carry or transmit torsional or bending stresses to which they may be subjected in normal operation without undue distortion or vibration.

The central turntable support of the scraper assembly may be constructed as a tower, consisting of properly braced vertical structural members, or it may be of reinforced concrete, or a combination of both. In either case the structure is designed to provide adequate support for the entire mechanism plus any possible live load with an adequate factor of safety. It can also be designed to give added sedimentation volume nearer the center of the tank above the sludge sump where increased settling space is particularly beneficial.

A horizontal motor-reducer mounted on a base plate fixed to a structural frame at the outer end of the bridge is connected by a flexible coupling to an enclosed chain drive running in oil. Electric current is transmitted to the motor through a conduit in the stationary center column by means of commutator rings. Keyed to the output shaft of the enclosed chain drive is a pinion gear which engages the underside of a rack anchored to the side wall of the tank. The upper edge of the rack forms a smooth rail path for wheels which carry the outer end of the bridge and walkway. This assembly serves to rotate the bridge and sludge scraper assembly. The motor reducer is provided with a safety switch arranged to open the motor circuit should an overload occur. Arrangement may also be made to sound an alarm if desired. The rack and pinion are submerged to eliminate difficulty from ice or sleet often experienced with traction driven clarifier apparatus.

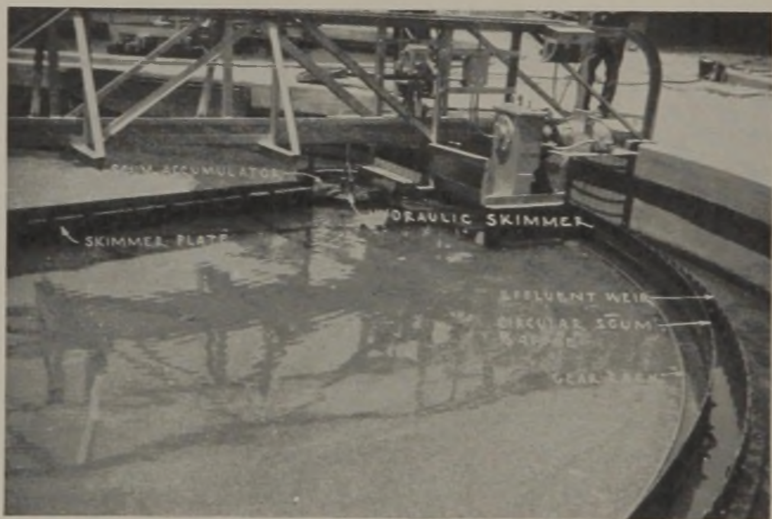


FIG. 3.—Closeup of the peripheral drive of the PD Clarifier showing the new Hydraulic Skimmer.

The PD clarifier lends itself to the addition of an annular effluent sand filter and cleaner device. The revolving bridge structure can be extended to carry the sand cleaner mechanism.

Primary clarifier mechanisms are equipped with the new Infilco hydraulic skimmer for the removal of floating scum. The mechanism consists of a skimmer plate suspended from the rotating bridge structure so as to collect and conduct floating material to a suitable scum accumulator or pocket in the skimmer plate near the tank periphery. To direct floating material to the accumulator a plate suspended between it and the circular stationary scum baffle is hinged so that one end is continually in contact with the accumulator. An Infilco hydraulic skimmer is connected to the suction side of a vertical centrifugal pump driven by a totally enclosed motor. The pump and motor are mounted on the rotating bridge structure at a point adjacent to the accumulator. The discharge pipe from this pump is arranged to deposit scum into a scum box which should preferably be located along the effluent collection channel remote from the point of effluent. The operation of this pump is controlled automatically by a cam and limit switch. An automatic starter is supplied to protect the motor and to take the skimmer pump out of service if desired. The scum box may be pipe connected to a scum sump for ultimate disposal of scum accumulation in any desirable manner.

The Infilco Hydraulic Skimmer (Figs. 2 and 3) operates on a principle that is completely new. The skimmer comprises a large circular horizontal plate

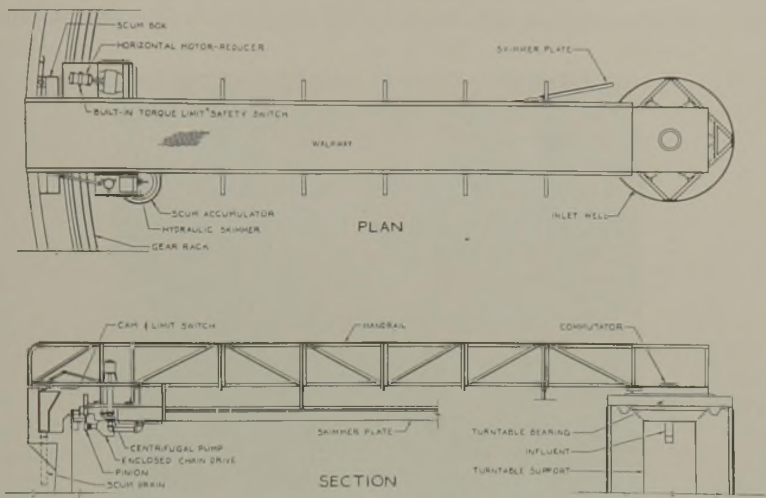


FIG. 4.—PD Clarifier-Skimmer.

with an opening in the center connected to the suction side of the scum pump. The plate is suspended from the bridge slightly below the surface of the liquid so that the pump suction produces radial currents towards its center. Scum accumulations are thus quickly and efficiently removed. The circular plate is adjustable vertically to provide for variations in scum thickness.

The enthusiastic acceptance of the PD clarifier mechanisms and hydraulic skimmers (Fig. 4) has been extremely gratifying. Those who have had an opportunity to observe these units have noted their unusually smooth quiescent operation and effective skimming.

JOHNS-MANVILLE

22 East Fortieth Street, New York, N. Y.

TWO NEW CLASSES OF TRANSITE SEWER PIPE

By C. A. McGINNIS, *Manager, Transite Pipe Dept.*

Two new classes of Transite sewer pipe, Classes 3 and 4 for use in culverts and very deep trenches, have recently been added to the Johns-Manville line. The addition of these new classes offers wider possibilities for taking advantage of the economies attributed to this asbestos-cement pipe for practically every type of service condition.

The properties of Transite sewer pipe make possible a variety of economies starting with installation and continuing throughout service. These not only include savings in the actual cost of installing the pipe, but also those made possible through a more economical design of the system. The weight of Transite per foot is from 25 to 60 per cent less than that of other materials. This, of course, means easier handling and aligning both in and around the trench. Only two men, for instance, are needed to lower a 13-ft. section of 14 in. Class 1 pipe into a deep trench, using rope slings and hand labor (Fig. 1).

Long 13-ft. sections facilitate the laying of the pipe. Comparatively flat gradients can be used, for alignment of the pipe is simplified, and once placed into position, long lengths are more stably restrained, thereby retaining their

FIG. 1.—Lowering a section of large-diameter Transite sewer pipe into a deep trench.

grade. And, of course, there are fewer joints to make up, so the line goes in faster.

With the widespread introduction of sewage treatment plants, the problem of minimizing infiltration is receiving the attention of progressive operators, since the infiltration of ground water may sometimes represent as much as 25 per cent or more of the total flow, necessitating not only greater operating costs but also plants of larger capacity. It has been estimated that a town of only 5,000 population can economically afford to spend an additional $25,000 to eliminate moderate amounts of infiltration from its lines.

To minimize infiltration Transite pipe is made in long lengths with specially designed joints. For gravity lines, Transite sleeve joints are used. The sleeve is placed over the joint and poured with a special asphaltic compound (Fig. 2). The ends of the pipe are furnished grooved and primed to assure a keyed joint in which the bond between the joint compound and the pipe wall is as strong as the compound itself.

For pressure lines the Simplex coupling is employed. This coupling consists of a Transite sleeve which is pulled over abutting ends of pipe, rolling into position and confining, two rubber rings. Pipe ends are factory-machined to effect a tight seal.

For making house connections into gravity sewers, a "cut-in" fitting is used since this type of connection can be introduced into the line as required at practically any point along the line. It gives a tight connection and is very easily made.

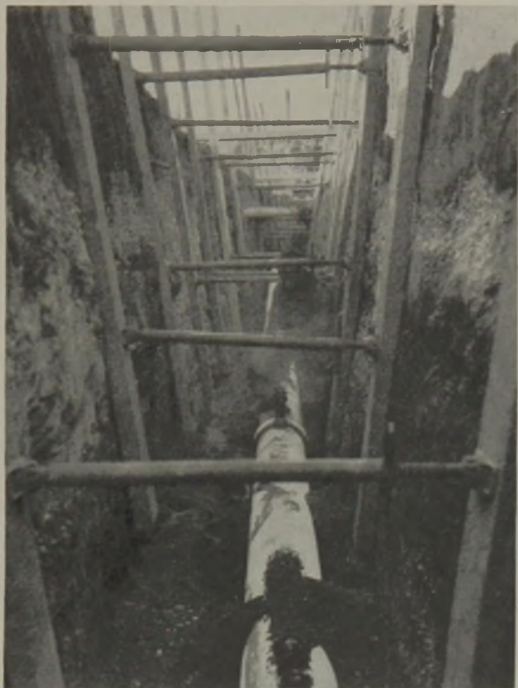


FIG. 2.—Pouring joint compound through a gate at one of the joints in a gravity line laid in a deep trench.

In discussing all-around economy, the subject of strength must be given due consideration. Frequently, sewer lines are buried 20, 25 feet or more, and the earth loads bearing down on pipe at these depths may reach relatively high values. Transite sewer pipe is made of an intimate mixture of asbestos fibres and cement, consolidated under extremely high pressure to develop unusually high flexural and crushing strength. Uniformity of the material is checked at the factory by subjecting each length to tests calculated to be equivalent to earth loading stresses for which the pipe class is recommended. With four classes to choose from, it is possible for an engineer to select the most economical combination.

This means taking advantage of a selection of strengths more nearly conforming with his design requirements. The heavier classes of pipe often offer an opportunity to eliminate the use of cradling which may effect substantial savings.

But perhaps the greatest economy which Transite sewer pipe can offer its user is directly attributable to high flow characteristics. The pipe is formed on polished steel mandrels which impart to the interior of the pipe a smooth, unbroken surface. It is this surface which is responsible for the high flows obtainable—a value of "n" = 0.010.

Also important in maintaining high flow capacity is the fact that the long lengths help in keeping pipe aligned and to grade. In pressure lines, pumping costs are reduced to a point where, often, the savings effected more than pay for the cost of the material. In some instances, the engineer finds it possible to use a smaller diameter pipe with no increase in pumping cost.

In gravity lines, savings are even more striking. Lines can be laid to flatter grades, eliminating deep trenches and effecting substantial economies in the cost of excavation. Calculations on one project involving about $3,000 worth of pipe show a saving of approximately $8,000 on these counts. This was effected by reducing the contemplated amount of soil and rock excavation and eliminating the need for a pumping station which, except for the flatter grades, would be needed to raise the sewage to the elevation of the treatment plant. Incidentally, these savings do not include the economy effected through speedier installation, reduction in labor, maintenance, and the number of flush tanks, etc.

Where it may not be desirable to take advantage of flatter gradients, appreciable saving can often be made by choosing a smaller diameter pipe than ordinarily required. Sometimes both are combined to advantage.

Although sewage may sometimes be substantially neutral, chemically speaking, it is also very often alkaline or aciduous, varying widely in degree of corrosivity, making a corrosion-resisting pipe material highly desirable. One of the special steps in making Transite converts the free lime ordinarily found in cement products into a group of lime-silicates, which are highly resistant to attack. Leaching tests by the Underwriters' Laboratories indicate this quality, but the corrosion-resistance of Transite has been practically tested in the field by many installations in all kinds of soil—alkaline, aciduous, cinderfill, salt marsh—and carrying a wide variety of sewage and wastes. Large quantities of this pipe have also been used for such special service as draining corrosive acid-bearing waters in mines; conveying salt water with oil residues in oil field service, etc.

The last decade has seen the development of many improved methods and materials for the more efficient handling and disposal of sewage. Treatment plants have sprung up at every hand, existing ones have been modernized, and much specially designed equipment has been developed. This extension of treatment has developed a greater consciousness of operating costs, a consciousness which inspired the introduction of Transite pipe into the sewage field. Numerous installations have proved that the design features inherent in this asbestos-cement material have afforded economies and efficiency in the installation, operation, and maintenance of modern sewer pipe systems.

LAKESIDE ENGINEERING CORPORATION

Water and Sewage Treating Equipment

222 West Adams Street, Chicago

THE AERO-FILTER

The Aero-filter is a high capacity trickling filter. Seven to eight times the capacity of a standard filter is obtained because the sewage is distributed evenly over the entire surface of the bed thus causing a continuous thin film of sewage to flow over all the surfaces of the media. This thin film in turn gives the flora on the media access to both the organic contents of the sewage and the oxygen so perfectly that *recirculation is not required* except in the nominal quantities necessary to maintain a minimum flow of 10 to 13 m.g.a.d. The only exception to this rule of no recirculation is when heavy sewages are being treated. In order to provide the fine and even dispersement necessary for Aero-filter operation, the Lakeside Engineering Corporation has developed several types of disc distributors, and multiple arm reaction distributors for filters over 34 ft. in diameter.

THE DISC DISTRIBUTOR

The disc distributors are motor driven. They break up the sewage into a rain-like spray and deposit it uniformly over the bed. The disc assembly (Fig. 1) consists of disc, collar and diffuser. The collar is screwed to the top of the riser pipe and has a skirt which overlaps a flange on the inner edge of

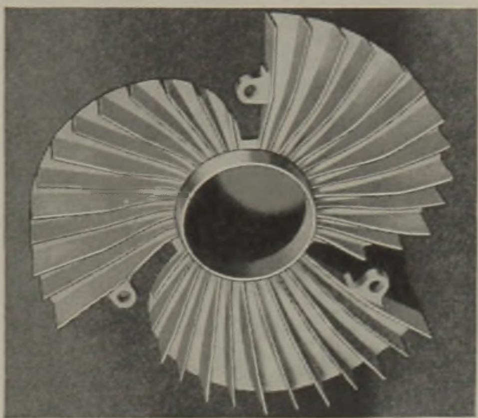


FIG. 1.—The Disc.

the disc, thus eliminating the need for a mercury seal. The diffuser, cast with curved veins, flows the sewage out onto the disc in the direction of rotation and enables the disc to engage the sewage into its rotation with a minimum of disturbance, thus cutting down on the power consumed. These discs are used on filters up to and including 34 ft. in diameter (Fig. 2).

ROTARY DISTRIBUTORS

The Lakeside reaction rotary distributors (Fig. 3) are unique in that they provide a uniformity of distribution on the larger filters that approaches that of the discs on the smaller filters. In order to accomplish this the number of arms increases with an increase in the size of the filter. For example, a 36 ft. filter is fitted with four arms while an 84 ft. filter has ten arms. In each case the arms branch at the point selected to give the most uniform coverage; thus, a 4-arm distributor has eight branches and a 10-arm distributor has twenty branches. These many-armed distributors provide a momentary distribution on a minimum of 20 per cent of the entire filter area at maximum flow, but because of their relatively high velocity they distribute the sewage in a manner that approaches the uniformity provided by the discs. Their peripheral velocity at the end of the branches is approximately 600 ft. per min. when operating at their maximum flow.

The center of the arms is placed about 12 in. above the top of the filter surface to provide sufficient clearance to accommodate the centrifugal type of nozzle. These nozzles spray the sewage upon the filter in a rain-like form with

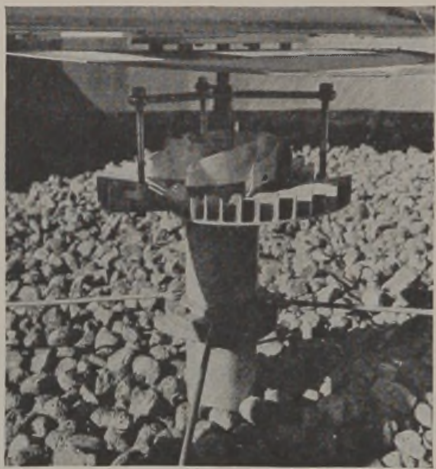


FIG. 2.—The Disc Distributor.

the result that excellent distribution as well as aeration is obtained. They are fitted with easily removable cover plates and are so connected to the arms that the angle of discharge may be changed at will and thus provide a simple method for adjusting the speed as well as the distribution. The nozzle orifices range from $\frac{7}{8}$ in. to $1\frac{1}{4}$ in. in diameter.

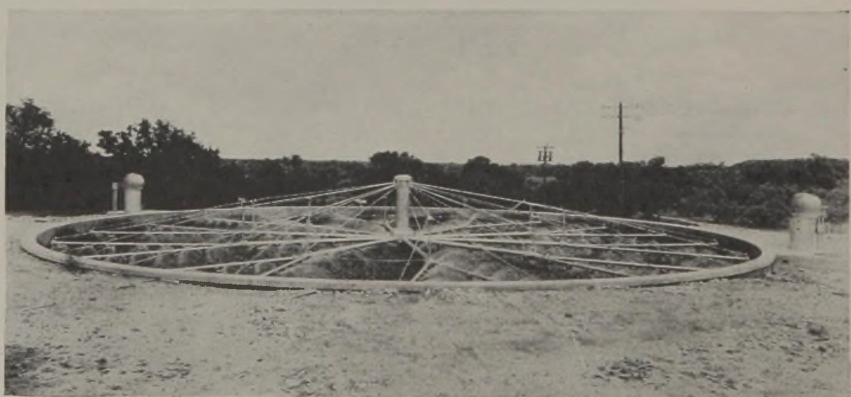


FIG. 3.—Rotary Distributor.

SPIRAFLO CLARIFIER

The Spiraflo Clarifier (Fig. 4) recently introduced by the Lakeside Engineering Corporation is unique in design. The sewage enters at the periphery of the tank and the settled effluent is collected in a circular weir trough at the center, a skirt, or baffle, is suspended within the tank to form a narrow race,

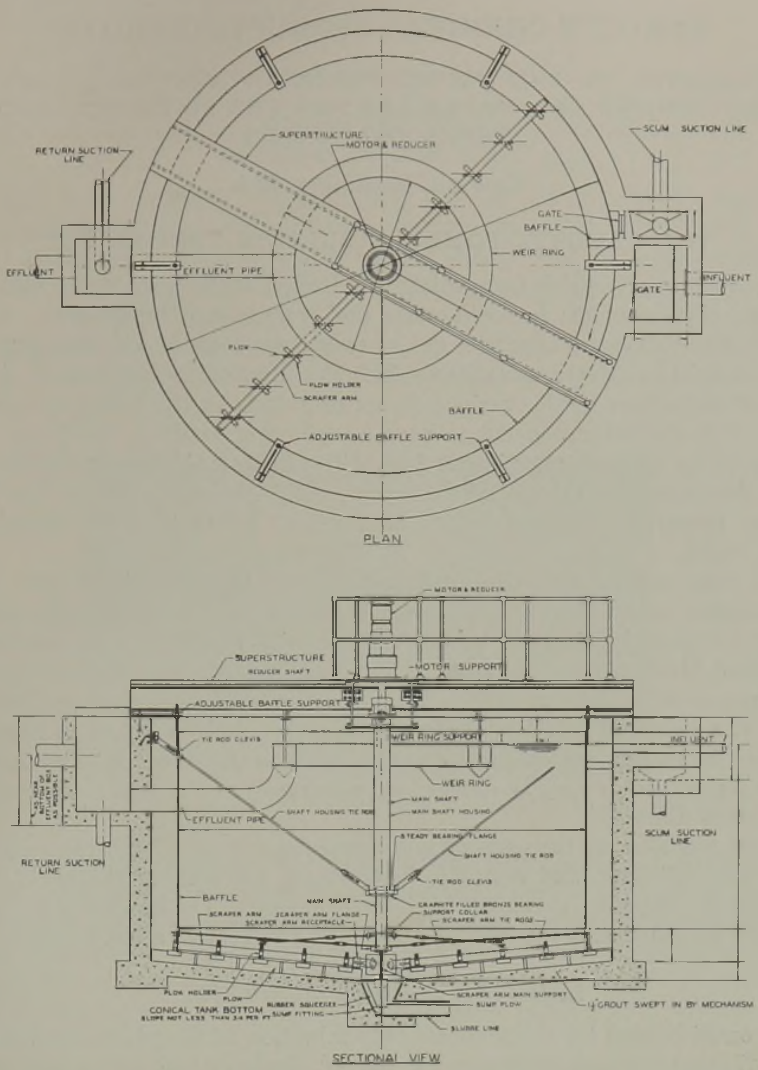


FIG. 4.—Spiraflo Clarifier.

open at the top and bottom, between it and the tank wall. The skirt extends almost to the bottom of the tank. The sewage enters near the top of the race in a tangential direction which causes a rotary movement spiraling downward, the sewage finally passing under the skirt and then, at a greatly reduced velocity, drops the heavier solids and passes upward through the sludge blanket. It finally overflows into the weir trough. The scum, grease and other floating materials collect within the race and are carried by the rotary movement to a collection box from which they are periodically withdrawn. A number of these clarifiers have been in operation for several years with satisfactory results. Their chief advantages are:

1. Perfect and automatic removal of scum.
2. A minimum of short-circuiting with improved detention.
3. Filtration of all sewage through the sludge blanket.
4. A very low velocity as settling action takes place.

LAMOTTE CHEMICAL PRODUCTS COMPANY

SPECIALIZING IN THE DEVELOPMENT OF TEST AND CONTROL EQUIPMENT AND MATERIALS FOR THE SCIENTIFIC AND TECHNICAL FIELDS

Towson, Baltimore, Md.

THE LAMOTTE-POMEROY SULFIDE TESTING SET

The presence of sulfides, especially hydrogen sulfide, in water and sewage creates a serious problem for both water and sewage works engineers. The odor constitutes a nuisance; concrete or ironwork exposed to sulfides deteriorates rapidly at fairly low concentrations. The handling of the problem is simplified if the concentrations of the various forms of sulfide in the water or sewage are known. It is also advantageous to have a method of analysis which can be used with simplicity and accuracy in the field. The LaMotte-Pomeroy Sulfide Testing Set was developed for this definite purpose, with the cooperation of Dr. Richard Pomeroy, Research Chemist of the Los Angeles County Sanitary Districts, Los Angeles, Calif.

Both total sulfides and dissolved sulfides can be determined with this set. Free hydrogen sulfide is calculated from the dissolved sulfides and the pH value. Hydrogen sulfide in air may be determined with the aid of an auxiliary kit. The method involved depends on the formation of methylene blue, in proportion to the amount of sulfides present. The color formed is measured by finding the amount of a standard solution of methylene blue that is required to produce the same color intensity in another test sample of the same volume. Concentrations up to 18 p.p.m. sulfide may be determined accurately. For higher concentrations the sample is diluted.

The set contains all the necessary glassware, a supply of the reagents for approximately 100 tests, and complete instructions for making the tests. All the equipment is compactly arranged in a portable case. The auxiliary kit provides equipment for aspirating a measured volume of air through a test reagent.

LAMOTTE SLUDGE pH OUTFIT

This outfit is used for the accurate determination of the pH of sewage sludges by the dilution method developed by Dr. W. Rudolfs and his collaborators, at the New Jersey Experiment Station. It may also be used in connection with the sulfide outfit, for the determination of free hydrogen sulfide in water or sewage. It covers a pH range from 5.2 to 8.4. pH determinations are made with this outfit without centrifuging or filtering.

All equipment, including instructions, is contained in a compact case.

LAMOTTE IMHOFF CONE STAND

This stand was designed to give a light weight, sturdy support for Imhoff Cones, without interfering with the reading of the graduated scale. It consists of a metal tripod to the top of which is securely fastened a fiber ring. This special ring serves to hold the cone securely and prevents actual contact of the glass with metal. Breakage is, thereby kept at a minimum. The tripod support decreases the possibility of tipping over and at the same time the entire scale on the cone is open to view.

LINK-BELT COMPANY

307 North Michigan Avenue, Chicago

LINK-BELT ANNOUNCES IMPROVEMENTS IN CIRCULINE SLUDGE COLLECTOR

The Link-Belt Circuline Collector for circular tanks consists essentially of a straightline-type conveyor and sludge plow mounted on a revolving bridge, supported at the center and periphery of the tank. The conveyor removes the settled solids into an annular covered sludge channel from which the sludge is withdrawn. The entire floor area of the tank is cleaned of settled solids during each complete revolution of the bridge, thus permitting a very slow rotation of the bridge and insuring minimum disturbance to settling and settled solids (Fig. 1).

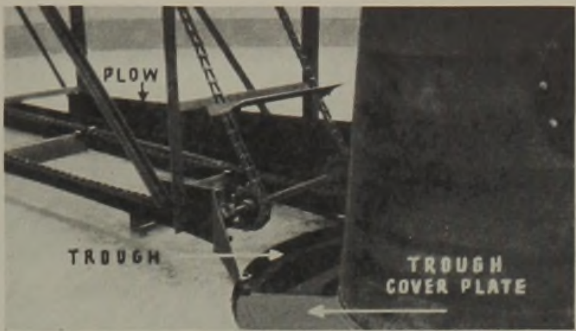


FIG. 1.—Link-Belt Circuline Collector annular covered sludge channel.

The sewage is introduced at the center of the tank through a conduit under the floor of the tank, which assures even distribution of flow throughout the tank. The machine is driven at the periphery. The drive consists of a self-contained motorized speed reducer carrying a sprocket which engages a heavy galvanized cable chain located and anchored in the effluent trough. The outer end of the bridge is pulled by the chain, or, it might be said, to literally "walk around"

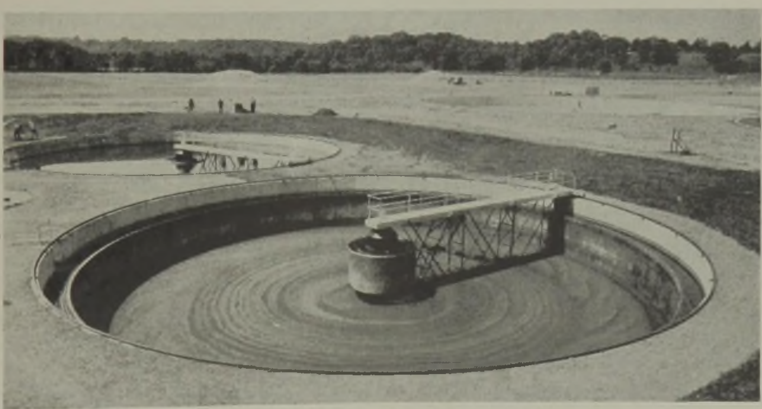


FIG. 2.—Two of four Link-Belt Circuline Collectors in final tanks of the sprinkling filter plant at Dayton, Ohio. M. W. Tatlock, Engineer and Superintendent. Each tank measures 80 ft. in dia. Two additional tanks with Circuline Collectors are now being installed.

the chain. It is provided with an automatic overload release which functions in case of excess loads.

Since the introduction of this type of collector in 1935, some sixty units have been installed in over twenty-two sewage treatment and water purification plants (Fig. 2).

Improvements in design and operating features recently made in this unit consist of the following:

(1) A separate screw conveyor (Fig. 3) which confines and moves scum to the scum box. This new feature prevents the wind from blowing the collected scum from the path of the skimming plate.

(2) Special processed rubber-tired wheels are now used in place of steel wheels, eliminating the T-rail tracks on the outside wall of the tanks. This feature reduces initial cost of the concrete tanks as track bolts do not have to be set

FIG. 3.—Close-up view of Link-Belt Circuline Collector in preliminary settling tank, at Quincy, Ill., showing the screw for removing scum. Engineers, Black & Veatch, Kansas City, Mo.

and provides an ideal method of supporting the outside end of bridge. Also, since this obviates the need of counterbalancing the machine, a better roller bearing design at the center column and a lighter, but more rugged, bridge construction are possible.

Because of the ability of the Circuline Collector to remove light, flocculent material, it has proven extremely satisfactory in use with the bio-filtration system.

BIO-FILTRATION SYSTEM

This system is a combination of high-rate filtration and recirculation of the effluent from sprinkling filters back to the detention tanks. With this system, the filter acts as the source of oxygen for the micro-organisms and the detention tank serves as a coagulation as well as a settling tank. It is recommended for new plants where better than primary effluents are required and for existing trickling filter or activated sludge plants which are overloaded.

Single-stage treatment is satisfactory for average requirements, but where a higher degree of purification is essential or where strong sewage or industrial waste is handled, the two-stage treatment is recommended.

This system is exceptionally flexible, as by varying the recirculation ratio the exact degree of treatment desired can be obtained at any time. The "recirculation ratio" is the ratio of the volume of the returned filter effluent to the volume of raw sewage entering the system.

As a rule the filter beds are 3 ft. deep. The size of the bed depends upon the pollution of the sewage and for ordinary domestic sewage a B.O.D. loading of 2 lbs. per cu. yd. of filter material is usually allowed. To obtain the same results as with a standard filter, a recirculation ratio of 2 will be required.

For a stronger sewage or industrial waste the two-stage treatment and a higher rate of recirculation is advisable, a higher B.O.D. loading being permissible under such conditions.

It is interesting to note, because of the features of low initial cost, high degree of purification and simplicity of operation, that the bio-filtration process is being used in nineteen army cantonments, forts and ordnance plants and other defense projects throughout the country. It is also now being incorporated in the design of many other projects under consideration. Some of these defense projects also employ the Link-Belt straightline-type of collector where rectangular tanks are used.

MABBS HYDRAULIC PACKING COMPANY

431 So. Dearborn St., Chicago, Ill.

IMPORTANCE OF USING THE PROPER PACKING

Thousands of dollars are spent annually for repairing and replacing of rods, plungers, shafts and valve stems in sewage treatment and disposal plants because the grit and dirt in the sewage handled score and wear these metal surfaces; but this does not happen when the proper packing is used. If a packing is used that becomes hard and glazed after several months use, then you know that this is not the proper packing, because it will hold on its surface, in a vice-like grip. the grit, sand and dirt, to wear and score with every stroke or revolution, the plunger, shaft or valve stem. The cost of these repairs in reality should be charged to the cost of the packing used in these positions, and if this were done, the engineers would find that the price they pay for the packing is prohibitive.

This expenditure for repairs can be eliminated by using Mabbs Rawhide Packing. It never wears and scores the mental surfaces, because it always remains too soft to hold the particles of grit upon its surface; they either wash away or work back into the body of the packing, thus preventing the wear and cutting of the metal surfaces, and making it possible to handle very gritty and sandy water without danger of damage to the rods, plungers, shafts or valve stems.

Here is what one engineer wrote about the Mabbs Rawhide Packing: "We have used this packing in one of our sand pumps and also in our Akins classifier. In both these machines packing glands are subject to the influence of highly abrasive pulps, and we have found the Rawhide Packing has stood up remarkably well, in fact, it has outlasted by far any previous packing that we have used."

Another wrote on May 11, 1940: "We have had wonderful success with your Rawhide Packing. On April 28, 1937 we put your packing in our two cylinder pump which pumps all the water for the town. It has been in use every day since that date without being touched. Prior to using Rawhide Packing we had to renew every two months; if not, particles would get through the entire system. Taking into consideration that the cost only being one ninth what it used to be, we have no hesitation in recommending your product to the limit.''

Another advantage of Mabbs Rawhide Packing is that it eliminates friction, and the beauty of it is that it requires absolutely no lubrication, except water. When rawhide is wet it's as slippery as an eel. Old timers will recall how slippery a rawhide whip used to get in the rain—in the old horse and buggy days. Rawhide Packing being frictionless, saves power and lasts an unusually long time.

The United States Government, fully realizing the importance of using the proper packing on its hydraulic dredges, where nothing but dirt and sand is handed, has been using the Mabbs Rawhide Packing for over 35 years.

When all these facts are taken into consideration—the saving in repairs and labor, the saving in power and the unusually long life of Mabbs Rawhide Packing—one discovers quickly that it is an economical packing and THE PROPER PACKING FOR SEWAGE PUMPS AND VALVES.

Upon request, samples and literature on this product will be gladly furnished by the Mabbs Hydraulic Packing Company, 431 South Dearborn Street, Chicago.

NIAGARA ALKALI AND ELECTRO BLEACHING GAS JOIN FORCES

AFFILIATED COMPANIES UNITE TO FORM ONE ORGANIZATION UNDER THE NAME OF NIAGARA ALKALI COMPANY

Niagara Alkali Company and Electro Bleaching Gas Company, two affiliated firms widely known throughout the chemical world for their pioneer activities in the field of alkalies and liquid chlorine, announce that they have joined forces and will operate as one organization under the name of Niagara Alkali Company. This move, which involves no change in personnel or policies, has been made to facilitate the operations of the two companies and increase the efficiency of the service each has been giving to customers over a period of approximately three decades.

The joining of the resources of Niagara and EBG is the logical result of their closely-knit producing, selling and distributing operations, which in recent years have become more and more a matter of joint rather than separate responsibility. Niagara Alkali manufactures caustic soda, caustic potash, carbonate of potash and paradichlorobenzene at its plant in Niagara Falls, N. Y. Electro Bleaching Gas Company, at its adjacent plant, produces by the electrolytic method, EBG liquid chlorine, which is familiar to users throughout the country.

Both EBG and Niagara are famous for their pioneering work in their specialized fields. EBG was the first American company to produce liquid chlorine, and was formed in 1907 for that purpose, with Mr. E. D. Kingsley as its founder and guiding spirit. In the years that followed, under Mr. Kingsley's leadership, the company assumed the burden of selling the textile industry, to its incalculable benefit, on the advantages of bleaching with liquid chlorine. Later, EBG introduced the use of liquid chlorine as a bleaching agent to the pulp and paper industry and the shellac industry. One of the company's outstanding achievements, however, was the adaptation of liquid chlorine to the purification of water supplies and the sterilization of sewage. As a result, chlorination is almost universal practice today in communities throughout the country and has been

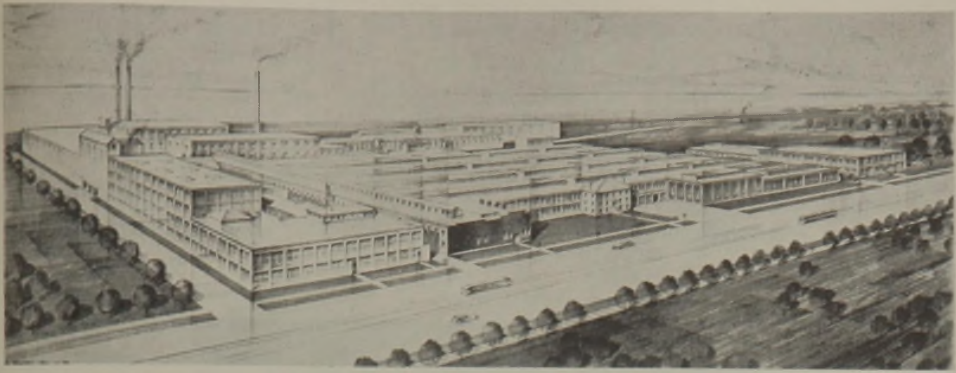


FIG. 1.—From this large modern plant at Niagara Falls, N. Y., Niagara Alkali Company serves its many customers throughout industry.

the means of saving thousands, and perhaps millions, of lives through the control of water borne diseases.

Niagara Alkali Company was the first to produce caustic potash in America. Recently, Niagara pioneered again and became the first American producer of carbonate of potash, used chiefly in the glass industry for the manufacture of fine glassware. This record of "firsts" is an enviable one, and combined with the achievements of EBG, constitutes an important and progressive chapter in the annals of the American chemical industry. It is expected by the management that the union of the two firms into one closely integrated organization will increase and simplify the value of the service given to users of their products throughout industry.

NICHOLS ENGINEERING & RESEARCH CORP.

ENGINEERS, CONTRACTORS, MANAGEMENT

60 Wall Tower, New York, N. Y.

NERCO ACTIVITIES—1940–1941

WHAT'S NEW AT INCINERATION HEADQUARTERS

The Annual Meeting of the Federation of Sewage Works Associations is a lodestone which attracts, from near and far, all who are directly or indirectly interested in sewage disposal. Engineers, operators, city officials, manufacturers are given this opportunity to meet and discuss what each has achieved during the preceding year; to listen in on the experiences of others; to offer a helping hand in the solution of some problem; to take home valuable information and a renewed incentive for the work ahead.

As the second Annual Meeting rolls around it seems fitting, therefore, that we, at Incineration Headquarters, should offer a brief report on the new thoughts and ideas, the new developments, the new equipment which we have brought into being since last September.

The disposal of sewage sludge, grit, screenings and scum; the disposal of garbage, of rubbish, of industrial wastes—these are the problems with which we have been engaged. We have tried to look at them from an objective standpoint, to find out what is needed by the men whose job it is to operate plants where these wastes are handled. Basically we believe these men look for three things: economy, dependability and simplicity.

NICHOLS HERRESHOFF Incinerator (Fig. 1) installations at 35 cities, handling sewage sludge filter cake, have proven that they satisfy the long need for complete and sanitary disposal of sewage sludge. During the past year we have placed in operation two full scale installations at Piqua, Ohio, and Ashland, Ohio, for the incineration of undigested, unfiltered liquid sludge. At both these plants, the raw sludge from the sedimentation tanks passes to a plain concrete concentration tank, which contains no mechanical equipment and requires no chemicals. Supernatant liquor, which readily separates from the sludge in the concentration tank, is returned to the head of the plant. The concentrated

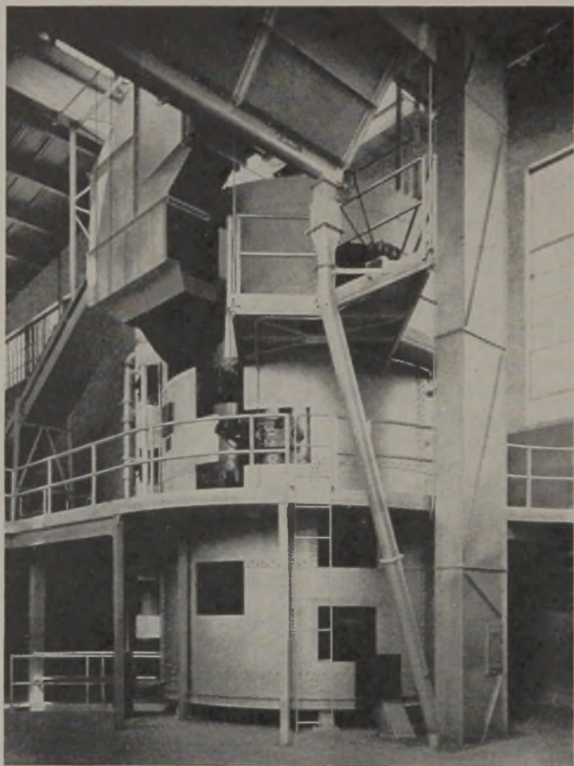


FIG. 1.—Nichols Herreshoff Incinerator at Wyandotte, Michigan.

sludge is then fed direct to the incinerator without further dewatering. A marked improvement in efficiency and economy has been obtained because of the simplicity of the operation and at both Piqua and Ashland only one man per shift is required to operate the entire plant. In addition, it has been found that the high heat content of raw sludge is distinctly beneficial to the operation and since the product from the incinerator is an inert mineral ash, the inclusion of digestion is not necessary. The auxiliary fuel required to evaporate the larger quantity of water in the incinerator is greater than when filter cake was incinerated, but the cost of this has been far offset by the many other savings obtained and at these two cities there is a substantial saving in power, chemical, labor and maintenance costs.

Turning to the disposal of municipal garbage, the trend has also been towards simplification. The city of Rock Island, Ill., has now completed a year's operation of their NICHOLS HERRESHOFF multiple hearth incinerator (Fig. 2) which handles sewage sludge filter cake, ground garbage or a combination of the two. The grinding of garbage, whether it is wrapped or is green, has proven to be a simple operation requiring very little attention except for the labor required for charging the grinder. The continuous mechanical stoking action of the NICHOLS HERRESHOFF Incinerator provides an ideal method of burning garbage since fresh surfaces are continually exposed for heat contact. It has proven its ability to burn ground garbage containing well over 70 per cent moisture without smoke or odor and without auxiliary fuel during operation.

Designs have been made for plants where the garbage will be ground and mixed with liquid sludge after the sludge has been thickened by decantation. The highly combustible garbage solids will thus have a beneficial effect by producing a mixture of higher heat value and lower moisture content for incineration.

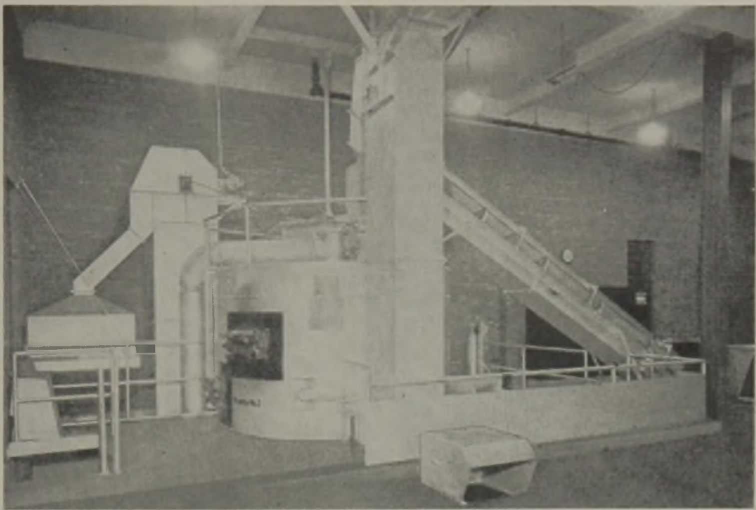


FIG. 2.—Nichols Herreshoff Incinerator at Rock Island, Illinois.

The incineration of sewage sludge and ground garbage in one incinerator at one plant greatly reduces construction costs and savings in labor costs are also obtained by combining both operations under one supervisory and operating staff.

The NICHOLS HERRESHOFF sludge drying installation at Dayton, Ohio, has now completed a year's operation. Digested sludge cake off drying beds is dried by means of warm gases admitted at the inlet end of the dryer and exhausted at the lower end. The dried product is granular in texture and the City of Dayton finds a ready market for it, the entire supply going to fertilizer manufacturers in Ohio. Here, again, the continuous rabbling action of the NICHOLS HERRESHOFF dryer provides a large surface for heat contact enabling the drying to be completed with the minimum of fuel and assuring a thoroughly dried uniform product.

Installations of this type should prove attractive to municipalities producing a sludge which is adaptable for use as a fertilizer and where a steady market can be found. As at Dayton, the same unit can be used for heat drying alone or for drying and incinerating sludge.

2. Sewage inlets and outlets which are dimensioned to eliminate clogging difficulties.
3. Periodic or continuous program of operation, depending upon the demands of local conditions. For example, an installation for pre-aerating purposes is being provided for a small plant handling 40 per cent domestic sewage and 60 per cent wastes from three local industries. As illustrated in the sketch, the pre-aerator is installed over the primary clarifier, permitting continuous conventional operation of the clarifier with operation of the pre-aerator at such times as occasion demands.
4. Its adaptability to batch or continuous flow conditions of treatment.
5. Indicated power requirements of approximately 2.5 H.P. per m.g.d. per turnover of the incoming flow. This may be compared with a diffused air system utilizing one cu. ft. of air per gallon at a 15 ft. water head, requiring indicated power of about 20 H.P. per m.g.d. treated. Thus eight turnovers of the incoming flow through the aerator may be provided with the same power required for diffused air treatment.
6. Air rates of approximately 7 cu. ft. per gallon of treated flow per turnover.

Development of the aerator is based on experimental work carried on over a period of a year at the Geneva, Illinois, Sewage Treatment Works. The investigations covered use of the unit for pre-aeration, for activated sludge treatment and for treatment of digester supernatant liquor.

Some of the results obtained are presented in the tables on pages 1077–78.

Although no results are recorded for aeration periods of less than 15 minutes on supernatant liquor, the excellence of the results obtained with that period indicated that shorter periods might be used producing a clarified liquor that may be safely discharged to a treatment plant without harm to the treatment process as a whole. After aeration, solids in the supernatant settled rapidly giving a well concentrated sludge, and allowed the withdrawal of clarified liquor.

Activated Sludge Treatment

% Ret. Sl. to Raw Infl.	Aer. Per. Hrs.	Turn-overs	Mixed Liquor S.S. p.p.m.	Sl. Index	Final TK Sett. Period Hrs.	D.O.		5-Day B.O.D.			Susp. Sol.		
						Mixed Liq. p.p.m.	Fin. Eff. p.p.m.	Raw p.p.m.	F.E. p.p.m.	% Red.	Raw p.p.m.	F.E. p.p.m.	% Red.
46.5	0.55	9	815	139	0.50	0.6	0	149	73	51.0	141	80	43.3
26.2	1.20	17	558	175	1.10	1.4	0.1	153	46	69.8	148	64	56.7
22.5	1.23	24	612	139	1.15	4.4	0.7	140	29	79.2	137	42	69.4
30.0	1.77	27	699	110	1.67	3.6	0.5	154	22	85.6	154	34	77.8

Note: Each set of determinations represents average for period of approximately one week.

The activated sludge tests showed no harmful effect on the settling qualities of the sludge floc from the action of the aerator, and an inferior sludge could be quickly restored to a well-activated condition. It is to be noted that the removals indicated are based on removals through the aerator and final tank and do not include "overall" removals. Hence the 85.6 per cent removal of B.O.D. when considered with results of the primary tank would indicate an "overall" removal of about 95 per cent.

The activated sludge studies were conducted solely on short aeration periods, i.e., periods of aeration of less than two hours, and were sufficiently conclusive to

Pre-aeration of Sewage

Influent			Pre-Aerated Effluent							
			One Turnover				Two Turnovers			
B.O.D. p.p.m.	D.O. p.p.m.	Temp. ° F.	B.O.D. p.p.m.	% Red.	D.O. p.p.m.	Temp. ° F.	B.O.D. p.p.m.	% Red.	D.O. p.p.m.	Temp. ° F.
243	0	56	186	23.4	6.0	53				
243	0	56	174	28.4	6.0	53				
382	0	53	361	5.5	4.1	50	329	14.0	6.9	47
			Four Turnovers				Eight Turnovers			
323	0	56	283	12.4	6.8	50	271	16.2	8.0	46
242	0	53	212	12.4	6.8	47	203	16.1	8.2	43
272	0	—	245	10.0	6.8	—	237	12.9	8.2	—

Note: Effluent from Geneva primary clarifier used as influent to aerator.

Treatment of Digester Supernatant Liquor

Continuous-Flow Tests

Supernatant Liquor		Aer. Per. Min.	No. of Turn-overs	Settl. Per. Hr.	Settled Liquor			
					Analyses		% Reduction	
B.O.D. p.p.m.	S.S. p.p.m.				B.O.D. p.p.m.	S.S. p.p.m.	B.O.D.	S.S.
1539	6192	18	5.8	1.1	204	200	86.5	96.8
1185	4212	20	5.8	1.1	183	204	84.5	95.0
672	1804	24	7.5	1.1	169	182	74.7	89.8
873	2816	36	11.2	1.1	187	201	78.5	92.7

Treatment of Digester Supernatant Liquor

Batch Tests

Supernatant Liquor		Aer. Per. Min.	No. of Turn-overs	Settl. Per. Hr.	Settled Liquor			
					Analyses		% Reduction	
B.O.D. p.p.m.	S.S. p.p.m.				B.O.D. p.p.m.	S.S. p.p.m.	B.O.D.	S.S.
542	1640	15	4	2	158	162	70.8	90.0
1042	3088	15	4	2	173	172	83.3	94.3
2512	10068	15	3.6	1.5	249	155	90.1	98.5
542	1640	30	8	1	173	218	68.0	86.7
542	1640	30	8	2	150	178	72.3	89.0
550	1228	30	6.4	1.5	174	188	68.4	84.6
1042	3088	30	8	2	167	180	84.0	94.1
1152	3056	30	8	2	194	196	83.2	93.5
2432	9088	30	7.8	1.5	237	180	90.3	98.0
2446	15484	30	7.1	2	179	158	92.7	99.0
2852	13840	45	12.7	1.5	235	174	91.7	98.5

demonstrate that satisfactory degrees of treatment could be secured with reduced periods of aeration with this type of aerator.

Other applications for which the device is suitable include:

1. Pre-aeration for,
   a. Reducing the load on secondary treatment units.
   b. Separation of grease. Location of the aerator in the primary clarifier will permit subsequent quiescent flotation of the separated grease therein.
   c. Conditioning of stale sewage for odor control and for improving the effectiveness of other plant units.
2. Activated sludge treatment. Operation of the experimental plant as an activated sludge process demonstrated its adaptability to economical use under conditions of comparatively short aeration periods.
3. Re-aeration of return activated sludge.
   Successful re-activation of deteriorated sludge was carried out during the tests, indicating application to problems of this nature.
   The installation of facilities for reaerating the return sludge in a separate unit of this type to take the place of, or to supplement, such corrective measures as increasing air rates to the aeration tanks, temporarily by-passing, or otherwise reducing the raw sewage load, or stepping up the wasting of sludge to build up a new healthy floc, would provide an economical and invaluable reserve against upsets.
4. Stage aeration in instances where particularly strong raw sewage is encountered.

The development work on this unit was conducted by the Pacific Flush Tank Company with the cooperation of the officials and operating staff of the Geneva, Illinois Sewage Treatment Works.

ROYER FOUNDRY AND MACHINE COMPANY

176 Pringle St., Kingston, Pa.

BATTLE CREEK SEWAGE TREATMENT WORKS HAS UNIQUE SLUDGE DISINTEGRATOR SET-UP

N. G. Damoose, Engineer of the Battle Creek, Mich. Sewage Treatment Works has rigged up a unique and practical sewage sludge disintegrating unit. It consists of a Model "SD" Royer Stationary Sludge Disintegrator fixed to a channel steel chassis mounted on large truck casters.

A Ford V–8 engine with radiator, muffler and instrument panel is also mounted on the chassis to supply power, by means of a belt, to the Royer machine.

Sludge cake is hauled from the drying beds in dump cars and deposited on a pile next to the digesters. It is shovelled into the hopper of the machine in coarse lumps and is discharged by the Royer directly into trucks for hauling to growers, parks, cemeteries and golf clubs.

The Royer handles sludge cake with a moisture content as high as 51 per cent, shredding, aerating and further drying it by means of a "combing belt." Sticks, stones and trash are automatically removed. An adjustable sweep at the discharge regulates the size of the finished product. A deflector controls the distance material is thrown in being discharged. It can be piled close up or as far away as twenty feet.

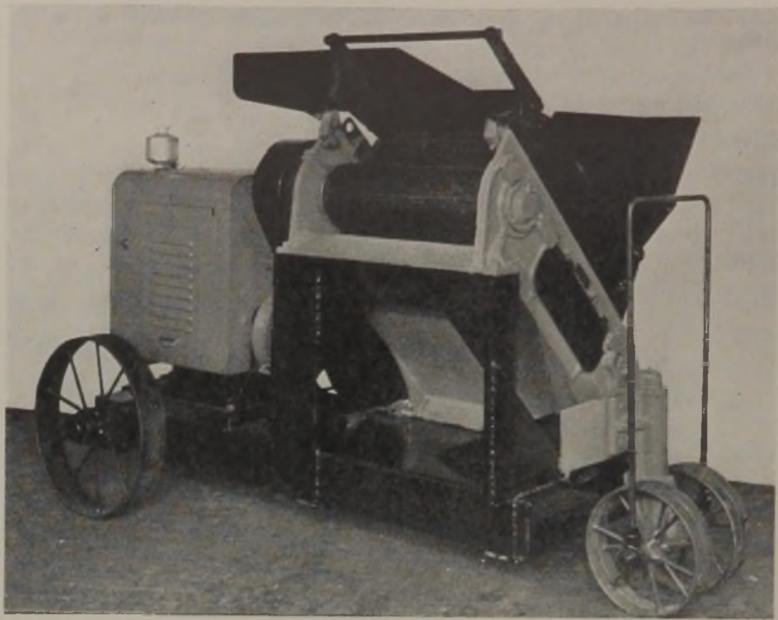


FIG. 1.—The largest portable Royer-Sewage Sludge Disintegrator so far built (for an eastern operator, who purchases sludge cake, shreds it, mixes-in enrichening chemicals and bags it for sale), a model "NSR-P."

FIG. 2.—Sewage Works, Battle Creek, Mich., showing Royer "SD" stationary sludge disintegrator and product.

The Model "SD" included in this set-up is one of twelve Royer electric, gasoline-engine and belt-to-tractor driven stationary and portable models.

More and more cities are turning sludge burial or disposal costs into profits by merely preparing sludge for use as top dressing or fertilizer with a Royer. All models readily mix in lime, ammonium sulfate or other enrichening materials,

FIG. 3.—Fort Wayne, Indiana, Sewage Treatment Plant: Model "SO" Royer Sewage Sludge Disintegrator preparing sludge for use by growers, by shredding, drying, aerating and removing trash (if any, such as sticks, stones, wires, etc.) from same. This is one of 12 stationary and portable Royer models.

sometimes added to increase the strength and value of the sludge. They also blend sludge and peat, sludge and sand or sludge and bone meal, thoroughly distributing the auxiliary materials throughout the sludge.

These machines are made by the Royer Foundry & Machine Co., 176 Pringle St., Kingston, Pa.

TENNESSEE CORPORATION

TRI-BASIC COPPER SULFATE, COPPER CARBONATE, SODIUM FLUOSILICATE, COPPER FUNGICIDES, MANGANESE SULFATE, COPPER SULFATE, ZINC SULFATE, FERRIC SULFATE (FERRI-FLOC), ES-MIN-EL

621–27 Grant Building, Atlanta, Ga.

FERRIC–FLOC is a modified form of ferric sulfate containing combinations of coagulants to enhance the coagulating power. Therefore it does not follow the rule based on ferric iron content. The effect of its ingredients increases its power to coagulate and therefore its value cannot be determined by reference to a ferric iron curve as applied to pure ferric compounds.

This feature in a coagulant is desirable since it permits the use of a salt of iron that needs no oxidation, nor does it have the insoluble characteristics of normal pure salts of ferric sulfate.

A partially hydrated salt such as FERRI–FLOC, because of the more stable properties of the partly hydrated materials, permits the use of ferric iron in this form under conditions normally unfavorable. Then to combine with this the high efficiency made possible by the addition of other coagulating materials affords the operator of a plant a desirable tool, with characteristics most favorable to his requirement.

Inexpensive adaptor for standard dry feeder for feeding FERRI–FLOC.

The scope of work done to date includes:

1. Sewage plants using FERRI–FLOC for chemical precipitation. Doses running from 0.5 to 3 grains per gallon.
2. Sludge filtration on vacuum filters with greatly reduced cost as compared to older methods. Amount required varying from 2¼ per cent per ton of dry solids to 10 per cent depending upon results desired.
3. Purification of packinghouse, paper mill and textile mill wastes by chemical precipitation with FERRI–FLOC.
4. Water treatment with greatly lowered doses as compared to alum.

With ferric iron now available at a cost comparable with copperas and alum and much less expensive in use, in most instances, because of its increased effectiveness, the profession is afforded a new and valuable tool.

Preliminary work conducted by sewage and water plant operators prompted the research work that resulted in the development of a modified form of ferric sulfate and it is now available as a standard chemical in daily use by many plants.

THE VAPOR RECOVERY SYSTEMS COMPANY

"VAREC" EQUIPMENT

CONSULTANTS, DESIGNERS, AND MANUFACTURERS OF GAS CONTROL AND TANK EQUIPMENT

Main Office and Factory

2820 North Alameda St., Compton, California

SEWAGE GAS CONTROL STANDARD IN MODERN SEWAGE TREATMENT PLANTS

By Richard C. Hall, *Chief Engineer*
Vapor Recovery Systems Company

Sewage disposal units today incorporate operating gas control refinements comparable to the most highly specialized process plant installations in the world. The Vapor Recovery Systems Company, with many years experience in the gas control and safety equipment manufacture, has developed a line of gas control safety devices for sewage treatment works that embody the latest engineering designs in this field.

The accompanying flow diagrams represent the latest controls in modern sewage treatment works, the upper diagram illustrating a Multiple Digester Unit and the lower diagram a Single Digester Unit.

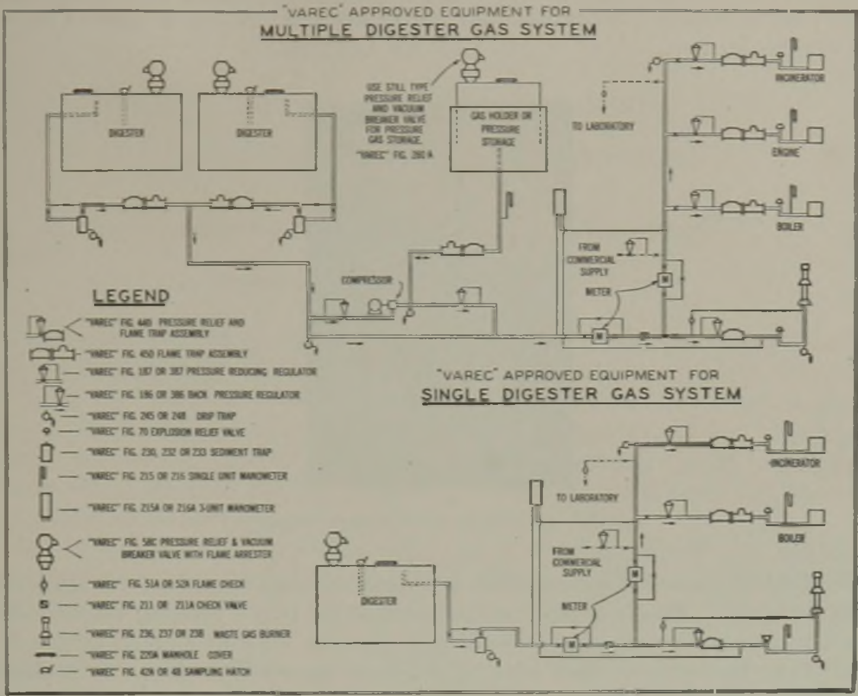


FIG. 1.

In the Multiple Digester Gas System, "VAREC" approved pressure relief and vacuum breaker valve with flame arrester (Fig. 1) is installed on the digesters and gas storage tanks to maintain system operating pressure and to protect the vessels in case of fire from without. Being constructed of aluminum throughout, they are noncorrosive, easily inspected, and maintained.

"VAREC" approved flame traps (Fig. 2) are installed throughout wherever there is a possibility of fire inside the plant piping. These units are made of corrosion resisting aluminum and afford a positive flame stop. All "VAREC" flame arresters are approved by the Underwriters Laboratories.

To maintain system pressure at the waste gas burner, a "VAREC" (Fig. 3) pressure relief and flame trap assembly is installed. This unit consists of a sensitive diaphragm—operated regulating valves in conjunction with a "VAREC" flame arrester, into which a thermally operated by-pass valve is built. In case of fire in the system, this by-pass valve automatically closes the regulating valve providing a positive flame check.

"VAREC" approved waste gas burners are manufactured with a wide capacity range and are furnished either with or without pedestal mounting, as required. The pilot valve gas line is protected by the installation of a "VAREC" approved flame check.

To handle sudden surges in pressure due to explosions or momentary plant fluctuations a "VAREC" approved explosion relief valve is installed in the system. Being dead weight loaded, it insures a positive and foolproof relief valve.

In plants where the gas is used to operate boilers, engines or other equipment, a "VAREC" approved pressure regulating valve is installed in the gas line to each piece of equipment. These valves are set to operate at a lower pressure than the "VAREC" (Fig. 3) pressure relief and flame trap unit, thus making sure that all the gas required is available for useful work before any is allowed to go to the waste gas burner.

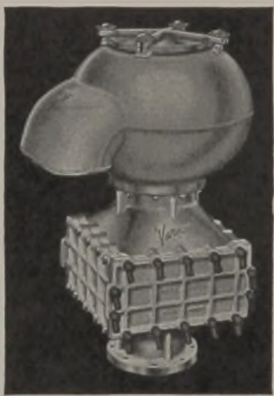


Fig. 2.—"VAREC" Flame trap.

"VAREC" approved manometers are used through the plant for indicating system pressure. They are obtainable in single or triple reading units with or without push button control. This latter feature is a built-in push button type valve that keeps the manometer shut off until the button is pushed. It is another "VAREC" engineered feature incorporating safety devices for should the manometer glass break, no dangerous gas is allowed to escape from the system.

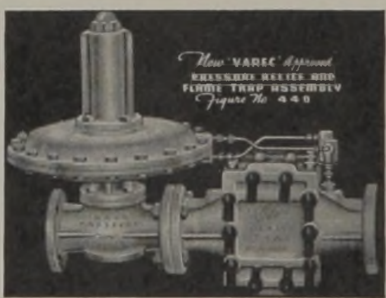


Fig. 3.—"VAREC" Pressure relief and flame trap assembly.

One of the basic design fundamentals in gas plant engineering is to keep the lines drained and free from moisture. A full line of "VAREC" approved sediment traps and condensate drip traps is available to meet this requirement.

The "VAREC" approved check valve is required in a system operating at low pressure. Designed for this purpose, its aluminum clapper cutting down the pressure required to keep it open.

"VAREC" non-sparking and gas tight manhole covers, installed on all tanks, provide a quick entry into the tank.

"VAREC" gauge and sampling hatches are also gas tight and non-sparking and have a foot pedal design to facilitate taking samples and gauges.

All "VAREC" regulating and control equipment is flow tested in the most modern type laboratory. Curves are published from each piece of equipment and can be used to determine the most economical size for each specific installation.

WAILES DOVE–HERMISTON CORPORATION

MANUFACTURERS AND CONTRACTORS
BITUMASTIC
PROTECTIVE COATINGS FOR INDUSTRY

General Offices, Westfield, New Jersey

Bitumastic protective coatings were first manufactured more than three quarters of a century ago. The forerunner of an unusual line of protective coatings produced by Wailes Dove-Hermiston Corporation was Bitumastic Enamel—developed to protect certain interior surfaces of steel ships subject to severe corrosion. Bitumastic Enamel soon became a byword among marine engineers as a coating which afforded lasting protection. Later, it was adopted for the protection of underground water, sewer, oil and gas pipe lines.

Out of this extensive experience in meeting the most diverse and difficult corrosion problems, new and individualized coatings, designed to meet specific corrosion conditions, have been added to the Bitumastic line from time to time. The most recent of these materials is Bitumastic No. 50—an unusual and exceptionally meritorious product extremely effective in protecting concrete and metal against corrosion.

Bitumastic No. 50 is a unique coal tar base black coating which is applied cold to an unusually heavy film. In the container it has the appearance of a plastic material too heavy to be readily applied. Stirring readily changes it to painting consistency; then it brushes out with no more effort than is required for the application of ordinary paint and may be sprayed, if so desired. For exceptionally severe conditions, a thickness up to $\frac{1}{16}$ of an inch can be applied in multiple coats on a vertical surface without any appreciable running or sagging of the coating while still wet. The spreading rate per coat is 75–200 square feet per gallon, depending on the thickness.

Bitumastic No. 50 is not an emulsion. This is an important point because emulsions all contain water, and one of the objects of all paints or coatings is to keep water from the metal surfaces. Neither does Bitumastic No. 50 contain any asphalt, which is also important, because asphalts are likely to disintegrate more or less rapidly with exposure and do not remain waterproof.

On metal surfaces it is recommended that Bitumastic No. 50 be applied to bare metal. However, Bitumastic No. 50 can be applied over old paints if well weathered, hard, dry and firmly adherent to the metal surface. Bitumastic No. 50, however, should not be applied over freshly painted surfaces nor should oil base paints be applied over Bitumastic No. 50.

Where a field primer and not a shop primer is required, Bitumastic No. 50

can be used for both the primer and the final coat. For use on concrete where a priming coat is required, it can be used both as a priming and a final coat.

After drying, Bitumastic No. 50 will withstand an atmospheric temperature of about 140 degrees F without sagging and—10 degrees F without cracking.

Bitumastic No. 50 spreads very easily and does not "drag or pull" on the brush. The common tendency, therefore, is to spread it out too thinly, thereby eliminating one of its principal advantages—a thick coating from a cold applied material. Hence, painters should refrain from spreading it out too much and use the brush as a sort of trowel to build up a heavy coat.

WALLACE & TIERNAN CO., INC.

CHLORINE CONTROL AND CHEMICAL FEED DEVICES

Newark, New Jersey

POTENTIAL CONTROL—THE CHLORINE WATCHMAN AT THE SEWAGE PLANT

For years it has been recognized by those familiar with sewage treatment that there is a great deal of variation in the chlorine demand of sewage. Coupled with this is a considerable fluctuation in sewage flow through any treatment plant. Flow variations can be quite readily determined but knowledge of quantity is of little value in determining total chlorine demand at a given moment, until it is associated with the corresponding chlorine demand in parts per million. Laboratory technique cannot provide a continuous picture of chlorine demand because determinations can be made only at intervals and peaks or valleys in the curve may readily occur between consecutive readings.

Until recently, therefore, there was no means of determining the maximum and minimum values of chlorine demand at a given sewage plant. The practice of chlorinating sewage to achieve 70 per cent to 90 per cent satisfaction of momentary chlorine demand has gained prominence as accepted practice but unfortunately, it has been necessary to carry on with a very limited knowledge of actual conditions or at best, by an approximation based on laborious and time consuming laboratory work.

The latest development of Wallace & Tiernan Research has changed all this. It is now possible to have a continuous curve of fluctuating condition of sewage at any plant, automatically recorded. Such a record will portray actual chlorine requirements, regardless of any variations in flow or the most extreme cases of fluctuation in chlorine demand.

Curves of electrical potential automatically recorded on a chart by this new W&T control device, have shown hitherto unsuspected fluctuations. The extent of these wide variations has been a revelation to W&T research men who have specialized in sewage treatment for years. Wallace & Tiernan sewage potential control has brought to light new conceptions of the requirements of sewage chlorination which, it is believed, make it newsworthy to the entire industry. Anyone familiar with sewage treatment recognizes the obvious fact that variations in flow and fluctuations in chlorine demand in parts per million combine to cause a wide range of values for total chlorine demand at any plant. It remains for this new product of W&T research and development to reveal the amazing extent of this combined effect.

How It Works

Developed primarily to meet the needs of the industry for a truly automatic means of control for sewage chlorination, W&T sewage potential control operates on an entirely new principle.

It has been established that the electrical potential of sewage is a direct indication of its condition. When the sewage is weak or more highly oxidized, the potential is high and when the sewage is strong its potential is low. Chlorine added to sewage increases its potential so that chlorinated sewage reacts in the same manner as weaker samples.

Taking advantage of this characteristic of sewage, the W&T sewage potential control employs a sampling cell to measure the electrical potential of the sewage being chlorinated. A small pump provides a steady stream of sample sewage which passes continuously through the cell. Recorded on a permanent chart is a continuous record of the potential of this sample stream. Records thus made at a number of plant scale installations have provided for the W&T research staff an entirely new understanding of the requirements for effective and economical chlorination of sewage.

The control device is so arranged that it may be set to maintain a desired potential after treatment. When deviations occur, operation is such that impulses are transmitted which make corrective adjustments to a W&T visible vacuum chlorinator. Adjusted by this means to the exact requirement of the moment, the rate of chlorine application is always such that a constant electrical potential of the sewage flowing through the plant is maintained.

The Wallace & Tiernan sewage potential control is therefore fully automatic. Rates of chlorine application are made to correspond to actual chlorine demand with respect to fluctuations in both variables—quantity and quality of sewage. It is obvious that the controlled potential may be so selected that any desired proportion of the immediate chlorine demand may be satisfied. For example, a number of plants indicate their desire to chlorinate to a value somewhat below complete satisfaction of chlorine demand. By adjusting the equipment to produce desired results, sub-residual chlorination with its attendant economy of chlorine, is completely reliable and will provide consistent results, regardless of variations of the quality and the quantity of sewage passing through the plant.

Studies of the electrical potential of sewage reveal a number of extremely interesting features. For example, it has been previously stated that the potential is a direct indication of the strength of the sewage. This has been established by exhaustive studies conducted in numerous plants under the direction of the W&T Technical Service Department. Another interesting feature indicates that it makes little or no difference whether the sewage is mainly industrial or entirely domestic—in terms of electrical potential,—the result is identical. Curiously, the addition of chlorine in small increments raises the potential of a strong septic sewage in such a way that it passes through all the intermediate points of weaker, more highly oxidized sewage, right up to the point where chlorine residuals can be measured in the usual manner.

Electrical potentials of very strong, septic sewage start at about minus 500 millivolts. Depending on the strength and condition of the sewage, these potentials range from this low value, through zero and then up to plus 250 millivolts which corresponds to sewage which shows a chlorine residual of approximately 0.5 p.p.m. The potential zone where chlorine residuals first become apparent has been extremely consistent with all sewages encountered in extensive investigations. Other potential zones do not show as consistently regular indications. Nevertheless by controlling chlorine application close to the zone where residuals begin to appear, consistently good results are obtained and 70 per cent to 90 per cent of chlorine demand satisfaction is to be expected.

Consistent with W&T policy throughout the years, this work has been going forward without fanfare or announcement for a considerable period. Several plants have been and are being operated on full schedule and results carefully studied. The equipment involved has been developed in line with findings in the experimental data to eliminate all operating difficulties and to compensate for conditions encountered in daily plant operation.

Advantages

Obviously the advantages of sewage potential control are great. Here is an automatic control for sewage chlorination which evaluates and compensates for the important and unpredictable variables of sewage strength and rate of flow. Tests indicate that great savings in chlorine consumption may often result while adequate chlorination is always assured.

Rates of flow vary considerably from day to day and there is usually little relation between the corresponding days of succeeding weeks. Many variable factors such as temperature, rainfall, and industrial activity are responsible for this. These same factors and others, also affect the strength of sewage and hence its chlorine demand in p.p.m. There are several instances of extensive study of this problem and at least one case in which a very elaborate system has been worked out for approximating the chlorine feed rate required at various times. This method, at best is only an approximation based on frequent laboratory determinations. Such a method involves a great deal of time and labor which can be completely eliminated by using W & T sewage potential control.

Storm flows and their effect on the amount of chlorine required have long been known as unpredictable variables. Studies in connection with W&T sewage potential control have discounted the theory that storm flows cause immediate dilution and therefore immediately reduce chlorine demand. Instead, the conditions automatically recorded indicate that a storm flow pushes concentrated sewage into the plant to such an extent that chlorine requirements may increase to double the former value, almost instantly. Continuation of the storm flow ultimately shows a steady drop in chlorine demand as more and more dilution takes place. By the time a storm flow of long duration has continued an hour or two, very little chlorine is required as a rule in spite of the fact that total flow may continue to be two or three times the normal dry weather flow. Only by lightning fast laboratory work could any manual means be employed to control chlorination with any degree of accuracy under these conditions. W&T sewage potential control automatically and almost instantly makes the necessary corrections in chlorine feed rate to meet even these rapidly changing conditions with accuracy and dependability.

Progress continues. Here is a new development which already has established a better understanding of the art of chlorination. W&T sewage potential control is a definite step forward. By no other means now available can sewage chlorination be controlled with the accuracy of this system which assures adequate treatment at all times with a minimum use of chlorine. "Chlorine watchman at the sewage plant" is a title which aptly describes this latest product of W&T research and development.

YEOMANS BROTHERS COMPANY

MANUFACTURERS OF YEOMANS PUMPS, SHONE SEWAGE EJECTORS, ROTARY AIR COMPRESSORS, VACUUM PUMPS, SEWAGE TREATMENT EQUIPMENT

1433 N. Dayton St., Chicago, Illinois

YEOMANS LEVELER FOR ROTARY DISTRIBUTORS

It is not uncommon to find that after several years of service, a trickling filter structure with rotary distributor has, because of bad sub-soil or other conditions, settled out of level. Aside from whatever ill effect this may have upon proper drainage of the filter effluent, this inclination of the bed structure will, if not compensated for in some way, soon cause serious injury to the thrust and guide bearings in the distributor mechanism and ultimate failure to function, due to

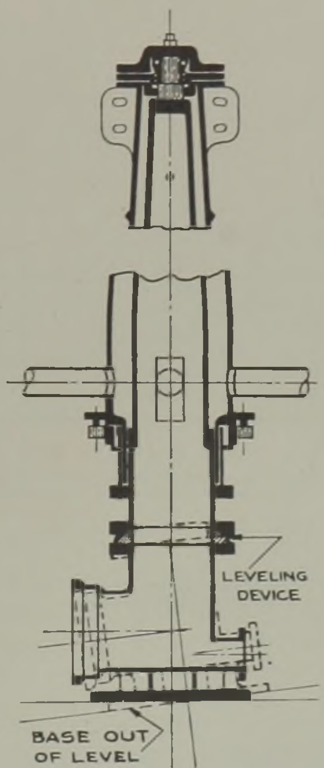


FIG. 1.—Cross section of distributor with Yeomans Leveler. Dotted lines show base out of level, distributor plumb.

the great stresses set up by unbalanced operating conditions. For example, in a distributor mechanism having 85-ft. arms and a rotating assembly weighing 10,000 pounds, the resulting horizontal component due to a 1° inclination might be as great as 175 pounds, and with a 5° tilt, 870 pounds.

In some instances, due presumably to insufficient support for the distributor base and consequent fracture of the floor of the bed, the bed and the distributor may settle unevenly, so that while on one side the arm ends may strike the stone surface, on the other, they may be 2 ft. or more above it.

In a distributor of the type in most general use, in which, as shown in Fig. 1, an outer column carrying the arms rotates about an inner column on which it is supported by thrust and guide bearings, it is obvious that the two columns must always be in concentric relation to each other. Hence if the outer column only is restored to a plumb position by lateral adjustment of bearings or guide rollers, axial misalignment will necessarily result in irregular operation of, and damage to, the mechanism. It then becomes necessary to dismantle the machine, break the inlet pipe joint at the bottom, relevel and regrout the base fitting and reassemble the distributor, a time consuming and costly operation and one which may have to be repeated in later years.

The Yeomans Leveler makes it possible to restore the vertical position of the distributor as a unit, without any dismantling of the mechanism or breaking of pipe joints, and with the use of ordinary wrenches. As shown in the illustrations (Fig. 1 and Fig. 2) the Leveler consists of a bronze ring with convex

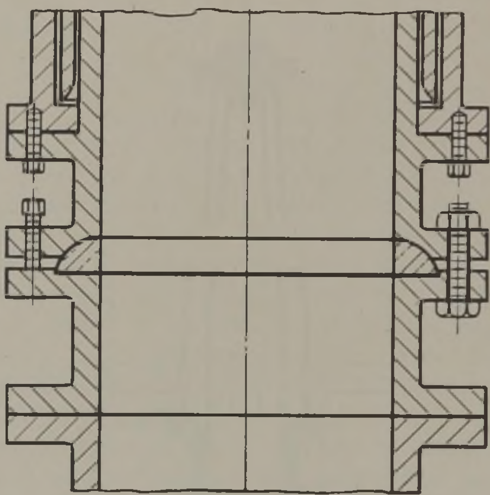


FIG. 2.—Detail of Leveler.

spherical upper surface, set in a shallow recess in the top flange of the distributor base fitting. A corresponding concave spherical surface in the bottom flange of the base of the inner distributor column or of a flanged pipe extension between the distributor column and the base fitting, forms a watertight adjustable joint with the ring, by means of which the entire distributor mechanism can be tilted several degrees in any desired direction. As the leveling ring serves to center the two flanges where they are parallel, extra large clearance holes, and, when necessary special self-aligning washers, are provided to secure adequate seating of bolt heads and nuts when releveling is completed. Forcing or set screws are also provided in the flanges for ease in releveling and for locking the flanges after the bolts have been set up.

The Yeomans Leveler can be furnished for application to existing distributors, but in such cases it is built as a complete sub-assembly with special flanges to be inserted between the base fitting and column flange already in place. This, of course, requires raising the distributor assembly but does not involve disturbing the base fitting or breaking and repouring the inlet pipe joint. The reduction in operating head due to raising the distributor is not more than 6 or 8 inches.

YEOMANS SEWAGE GAS BOOSTERS

The Yeomans Sewage Gas Booster is a recent adaptation of a high speed, sliding blade compressor which has been extensively sold for the operation of pneumatic sewage ejectors and other purposes since 1928. It has a capacity range of from 20 to 500 c.f.m. of free gas, actual delivery, at discharge pressures up to 50 p.s.i. and all sizes are suitable for direct connection to 1750 r.p.m. drivers. It is equipped with roller bearings, special composition blades which are not affected

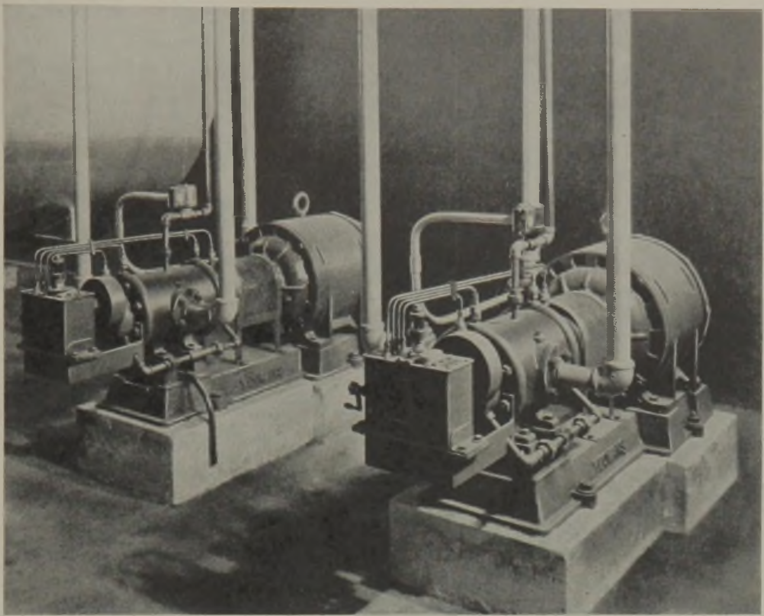


Fig. 3.—Yeomans Sewage Gas Boosters at Duluth Treatment Plant, Burlingame, Hitchcock and Estabrook, Engrs.

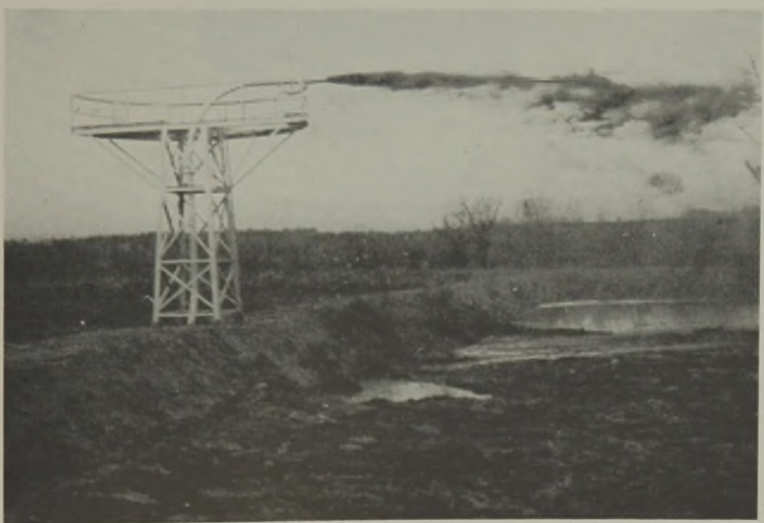


Fig. 4.—Packinghouse ejector discharge over drying lagoons at South St. Paul Treatment Plant.

by hydrogen sulfide or moisture and do not wear the cylinder walls. The shafts are equipped with water cooled, leakproof metallic seals with automatic take up requiring no attention. Large capacity, force feed, mechanical lubricators, mounted on outboard cylinder head and direct geared to compressor shaft, provide a continuous flow of oil to shaft seals, bearings and rotor blades, only when the compressor is running.

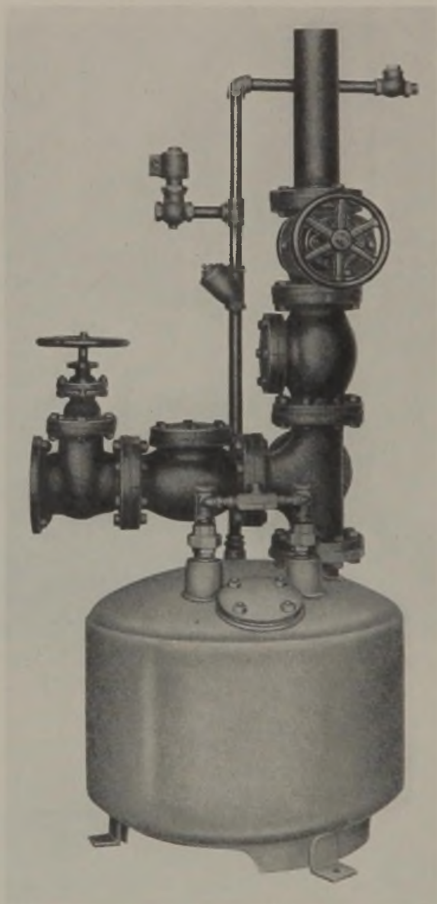


FIG. 5.—Yeomans Pneumatic Sewage Expelsor.

The great advantage of this booster is the fact that it does not employ splash lubrication and all used oil and condensation are immediately and constantly expelled through the discharge opening with the gas, so that there is no possibility of production and accumulation of sulfuric acid within the machine which may attack metallic surfaces. Also, that owing to the multicellular design and high speed, the gas flow is free from pulsation. They are quiet in operation, free from valves, belts or other forms of speed reduction, require but little floor space and are light in weight. They are in use in sewage treatment plants at Duluth, Minn.. Hammond, Indiana, and Beaver Dam, Wisconsin.

YEOMANS PACKINGHOUSE WASTE EJECTOR

This pneumatic ejector was specially designed to handle large volumes of paunch manure and other packinghouse wastes with a very high solid content which cannot be successfully pumped with either centrifugal or plunger pumps.

It has a receiver capacity of 200 cu. ft., with hopper inlet and automatic air operated inlet valve and distributes waste from conveyor belts through an elevated high pressure nozzle over drying lagoons. It has no discharge check valve and being operated by automatic electrode control, no moving part in the ejector except the inlet valve. One such ejector is now in successful operation at the South St. Paul, Minnesota Treatment Plant which was built to specifications of Messrs. Consoer, Townsend & Quinlan, Consulting Engineers, Chicago.

YEOMANS SEWAGE EXPELSOR

This is a compact and inexpensive form of pneumatic sewage ejector with top inlet and discharge, electrode control and hermetically-sealed steel pot without stuffing boxes, thus proof against leakage of sewage containing pathogenic bacteria, or explosive and asphyxiating gases. All conduit connections are water tight so that it will operate submerged. It requires no screens, shredders or wet well; has no moving parts; air compressor ventilates the pit and excess air pressure is available for clearing obstructed discharge lines. It will pass any solids that will go through the 4 in. minimum size valves and fittings. Single units up to 100 gal. per min. can be installed in pits 4 ft., duplex 6 ft. 6 in. round or square. It is offered with Yeomans rotary compressors or for operation from general air supply, as a clog-free substitute for small centrifugal sewage pumps.

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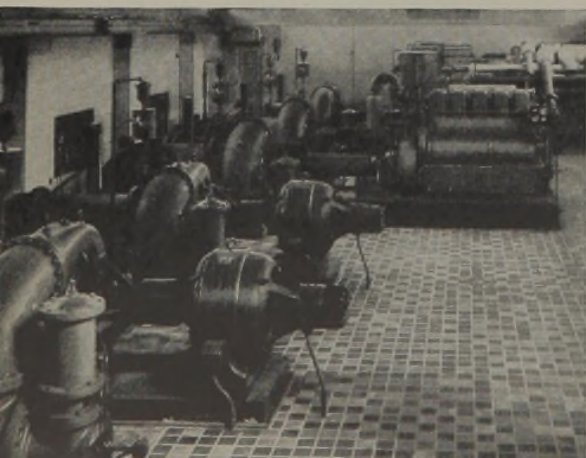
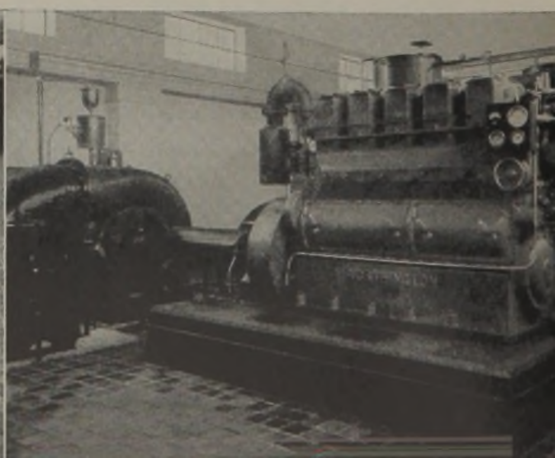
Two views at Gary, Indiana





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. . . is contributing prominently to the solution of sewage plant problems

Developments in the use of sewage gas engines find Worthington in a noteworthy position as evidenced by an extensive and constantly increasing list of successful installations.

And Worthington's service to the sewage disposal field includes not only sewage gas engines. Main raw sewage pumping units as well as pumping equipment for all auxiliary services will be found in a large percentage of our modern sewage disposal plants, including many of the most prominent installations.

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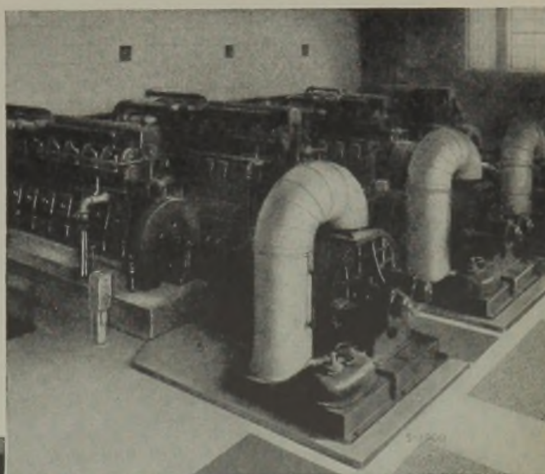
Representative of many outstanding Worthington installations are those at **TALLMAN'S ISLAND, New York,** *and at* **GARY, Indiana.**

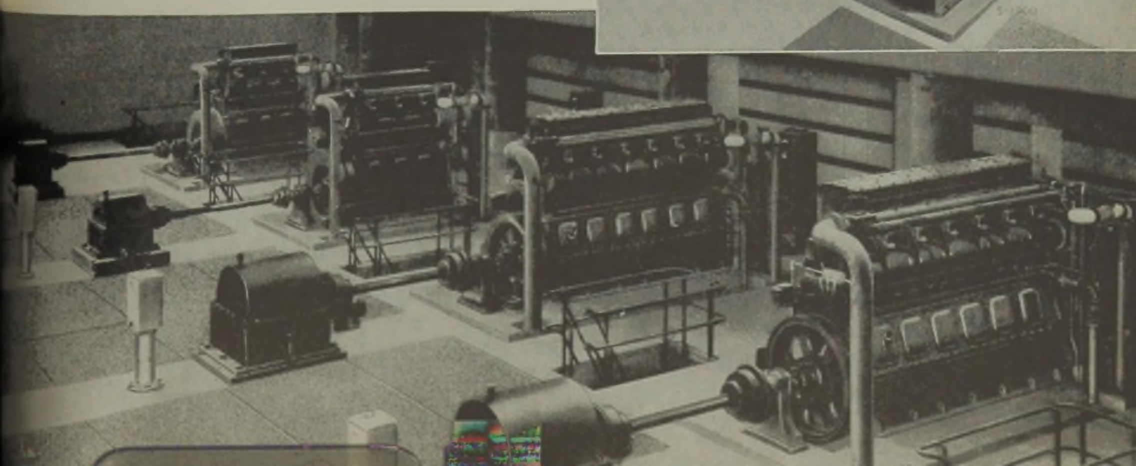
At **TALLMAN'S ISLAND** *are two 360-hp. and two 180-hp. Worthington engines, operating on sludge gas, driving Worthington vertical centrifugal sewage pumps through Falk right angle gears. Also, at Tallman's Island are two 845-hp. and two 460-hp. Worthington engines, operating on sludge gas, direct connected to Roots-Connersville air blowers for aeration service.*

At **GARY, Indiana,** *are three Worthington 24-inch centrifugal pumps, each of 20 MGD capacity, 35-feet TDH, driven by Worthington 175-hp. engines operating on sewage sludge gas. Also, two Worthington 20-inch centrifugal pumps of 15 MGD capacity, driven by 125-hp. Ideal synchronous motors. An installed capacity of 90 MGD, for handling raw sewage.*

IC1-36

At Tallman's Island





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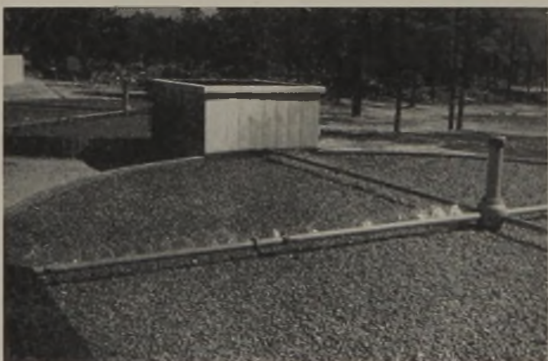
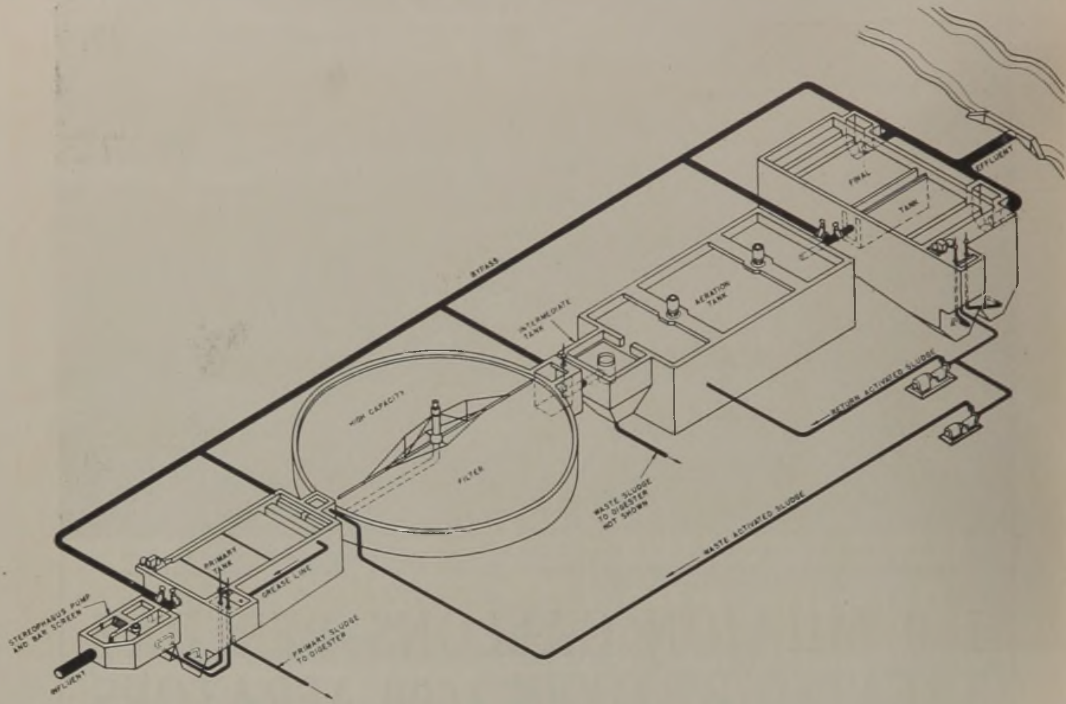


AMERICAN BIO-ACTIVATION



BIO-ACTIVATION PROCESS

For years the American Well Works experimented on the development of a sewage treatment process to produce a stable crystal clear effluent, although the influent sewage possessed characteristics that would stress or upset a standard activated sludge plant. The result:—A bio-activation process combining the biological filter and the activated sludge processes operating in series under optimum conditions at maximum efficiency.

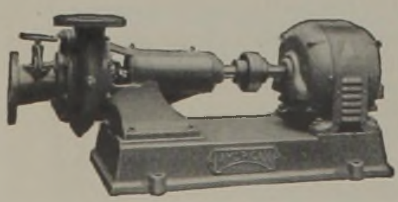
It is a well established fact that a trickling filter is a very "tough" sewage treatment agent and is capable of handling shock loads, high strength and septic sewages without the upsetting tendency of a straight activated sludge process. A properly constructed trickling filter will always produce a reasonably good quality effluent, even though abused or overloaded. The first two or three feet of media remove practically all of the B.O.D. and the remaining stone serves only to polish the effluent.

The activated sludge process is highly efficient, but the results are unpredictable especially during periods of dry weather or where unusual industrial wastes are encountered. It will deliver a high quality stable effluent when operating under ideal conditions, namely, when handling fresh dilute sewage containing dissolved oxygen.

In the bio-activation process, a relatively small amount of media is used in the trickling filter to obtain that first high efficiency of B.O.D. removal and introduction of dissolved oxygen. The partially oxidized and very fresh trickling filter effluent is then treated by the activated sludge process.

It is desirable to dose sewage over the surface of the high capacity filter at fifteen second intervals to each unit area. This will be best accomplished with a positive drive distributor. If a positive drive distributor is not used, it will be necessary to employ recirculation through the filter to obtain the same condition.

The aeration tank is designed on a relatively short retention period. This is permissible due to increased treatability and reduced strength of the filter effluent together with the elimination of shock loads. It has been demonstrated that it is feasible to treat fresh sewages running from 75 to 80 p.p.m. B.O.D. with an hour to an hour and a half retention period in the activated sludge tanks.



American Comminuting Sludge Pump. Extensively used for handling tough Primary Sludges and recirculation of digester contents.

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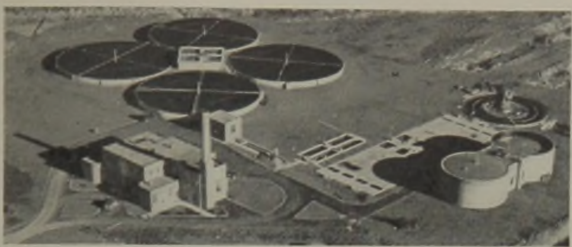
For Solutions to Your Sewage

METERING AND CONTROL PROBLEMS



One of the many newer Sewage Treatment workings using SIMPLEX metering equipment

From the minute the raw sewage enters the modern sewage plant to the final clear effluent, there is a SIMPLEX METER specifically designed for the accurate measurement of the flow.

If you are designing a new plant or planning to revamp an old one, SIMPLEX METERS will make efficient operation easier.

Write us about your problems today—check with the SIMPLEX ENGINEER who has gained the knowledge of accurate measurement and control from years of practical experience. Let us refer you to some actual installations in your vicinity. No obligation on your part, of course.

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SIMPLEX VENTURI TYPE METERS FOR MEASUREMENT OF WATER, SEWAGE, SEWAGE-SLUDGE, AND AIR; RATE OF FLOW CONTROLLERS; SIMPLEX PUMP CASING TAP METERS; WATER LEVEL GAUGES; SEWAGE AIR RELEASE VALVES; PROPORTIONAL CHEMICAL FEEDING DEVICES; HYDRAULIC EQUIPMENT OF SPECIAL DESIGN; SUMMATORS, AIR DIFFERENTIAL METERS, SIMPLEX GYROMETERS; IMPACT, VENTURI AND EGG-SHAPED FLUME METERS.

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PLEASE PASS ALONG
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ROCK ISLAND USES ONE INCINERATOR

FACED by the necessity of disposing of its Sewage and Garbage, the city of Rock Island, Illinois, decided that, economically, the logical procedure would be to build one plant to do both jobs.

To ensure complete flexibility in operation, the Incinerator was specified to meet the following exacting requirements:

1. **To incinerate a combination of green garbage and sewage filter cake.**
2. **To incinerate green garbage alone.**
3. **To incinerate sewage filter cake alone.**
4. **To operate under strict guarantees on any of the above bases.**

When you have a problem in the disposal of sewage sludge, or garbage, or both, write "Incineration Headquarters" and take advantage of the authoritative service, backed by wide experience and intensive research, which we can give you.

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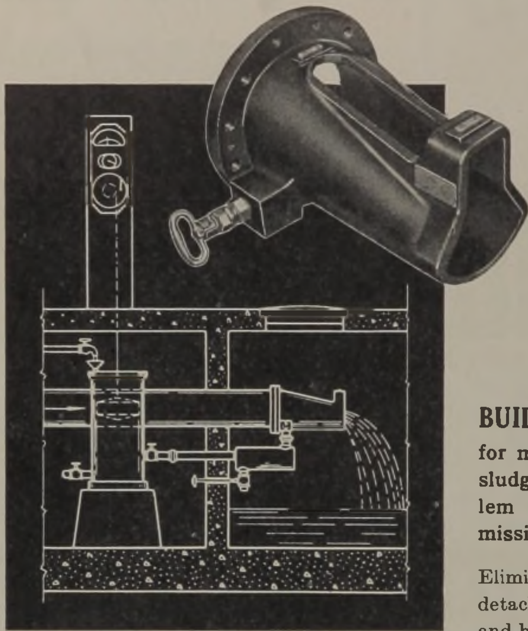

Type M Register-Indicator-Recorder Connected to Kennison Open Flow Nozzle

KENNISON NOZZLE
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Accurately measures flow in partially filled pipes and open channels.

Simple, economical, accurate, and trouble-free, Kennison Nozzles have been widely installed for measuring raw sewage, sludge or effluent. Available in sizes from 6″ to 36″ diameter.

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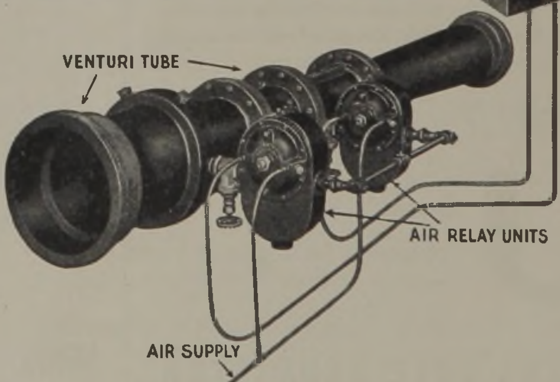
for metering sewage and sludge, solves the problem of intra-plant transmission.

Eliminates sediment tanks, detached wells, float pipes and head pipes; heavy piping replaced by small copper tubes. . . . Instruments may be placed up to several hundred feet away from Venturi Tube, or may be grouped with other instruments on central panel regardless of hydraulic gradient conditions. . . . Maintenance reduced to minimum; sediment-bearing liquid positively prevented from entering air piping or instrument chambers. . . . Accuracy and sensitivity are noticeably improved. . . . Time-proved mercury U-Tube principle for instrument operation using BOTH inlet and throat pressures from Venturi Tube.

DISTANT TRANSMISSION

Sewage disposal plants frequently cover large area and it may be desirable to have readings of flow rates, tank levels, valve positions, etc., brought to a control center. The Chronoflo Meter is particularly suitable for meeting a large variety of requirements involving direct transmission and summation of individual meter readings.



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