SEWAGE WORKS JOURNAL

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Special Features

Report of Research Committee

Design Without Critical Materials—Langdon

Operators' Sessions at Cleveland Conference

Addition of Sodium Nitrate—Heukelekian

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SEWAGE WORKS JOURNAL

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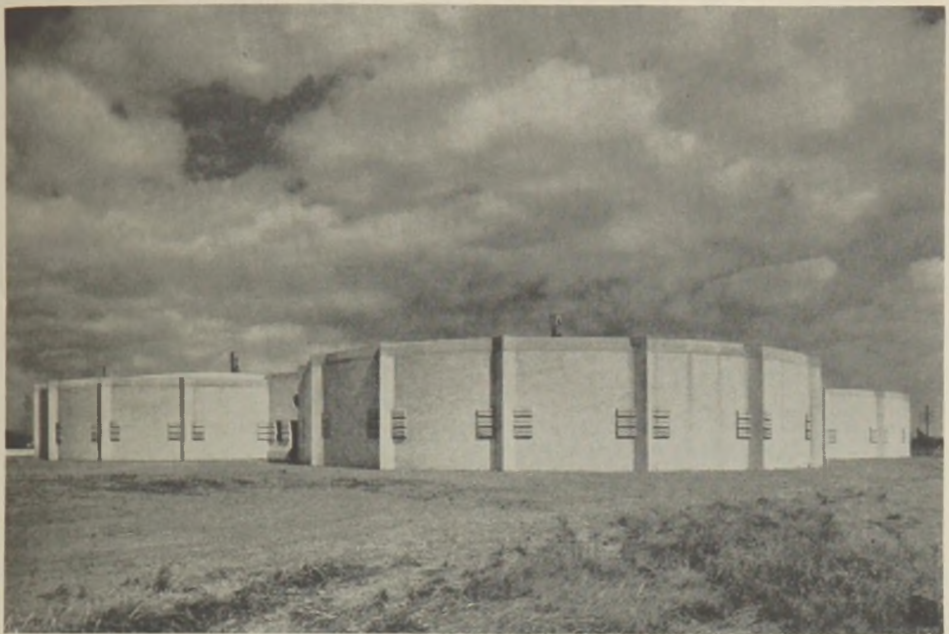

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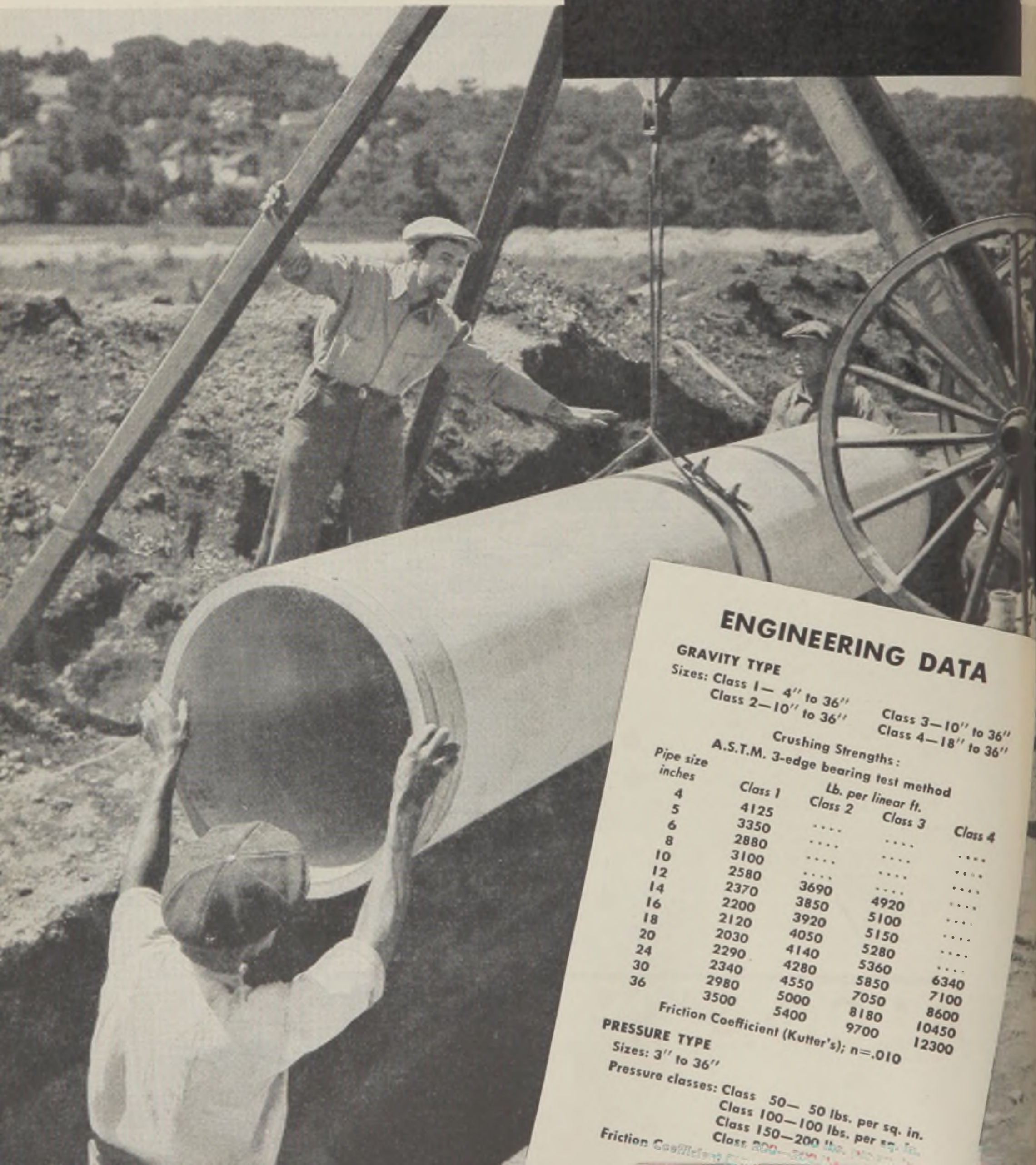


ENGINEERING DATA

GRAVITY TYPE

Sizes: Class 1— 4" to 36"
Class 2—10" to 36"
Class 3—10" to 36"
Class 4—18" to 36"

Crushing Strengths:
A.S.T.M. 3-edge bearing test method
Lb. per linear ft.

Pipe size inches	Class 1	Class 2	Class 3	Class 4
4	4125	....	....	....
5	3350	....	....	....
6	2880	....	....	....
8	3100	....	....	....
10	2580	3690	4920	....
12	2370	3850	5100	....
14	2200	3920	5150	....
16	2120	4050	5280	....
18	2030	4140	5360	6340
20	2290	4280	5850	7100
24	2340	4550	7050	8600
30	2980	5000	8180	10450
36	3500	5400	9700	12300

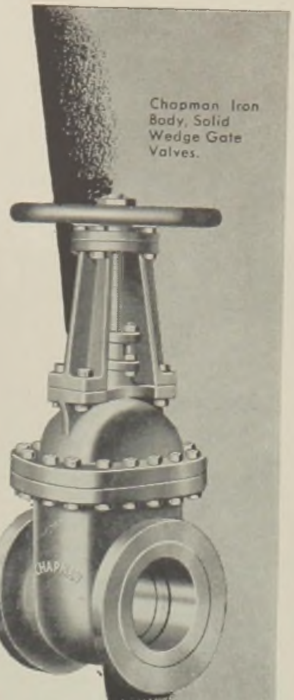
Friction Coefficient (Kutter's); n=.010

PRESSURE TYPE

Sizes: 3" to 36"
Pressure classes: Class 50— 50 lbs. per sq. in.
Class 100—100 lbs. per sq. in.
Class 150—200 lbs. per sq. in.
Class 200—

Friction Coefficient


Chapman Beamed Waterway Gate Valve with Hydraulic Operating Cylinder
92
CHAPMAN
"Beamed Waterway"
GATE VALVES
FOR
TENNESSEE'S
VOLUNTEER
ORDNANCE WORKS...
18 CLASS A
CHAPMAN
50 WP
Chapman Standard Sluice Gates, a Complete Line, with all Types of Operating Mechanisms



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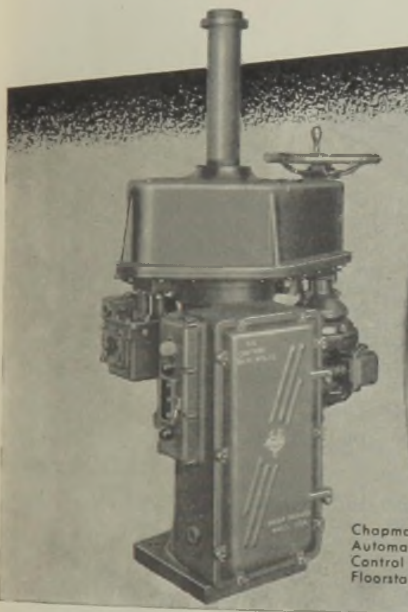

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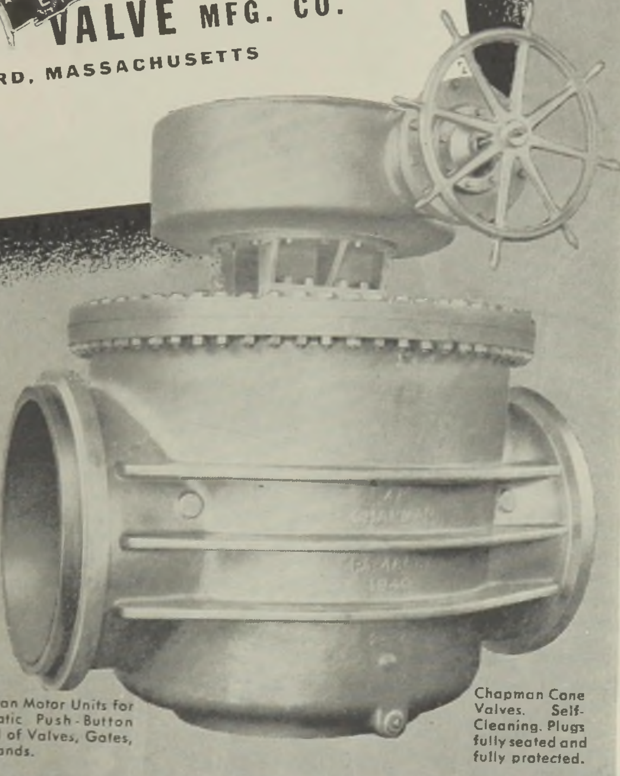

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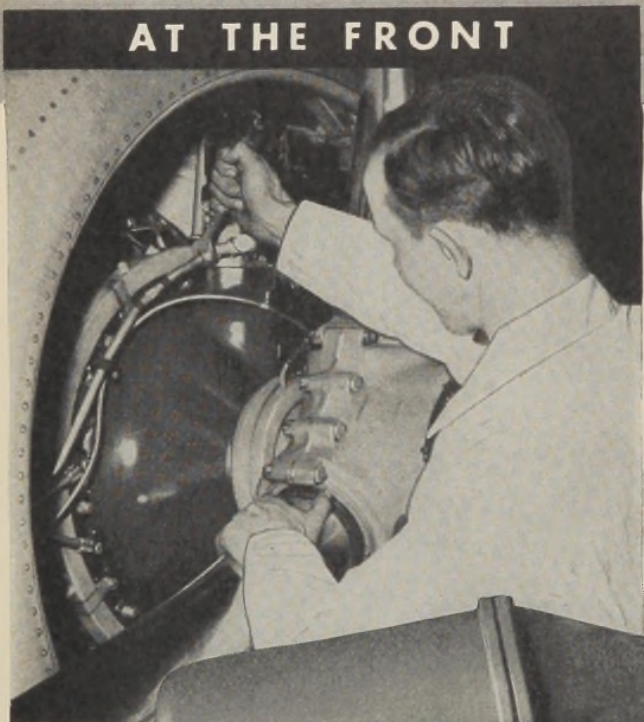
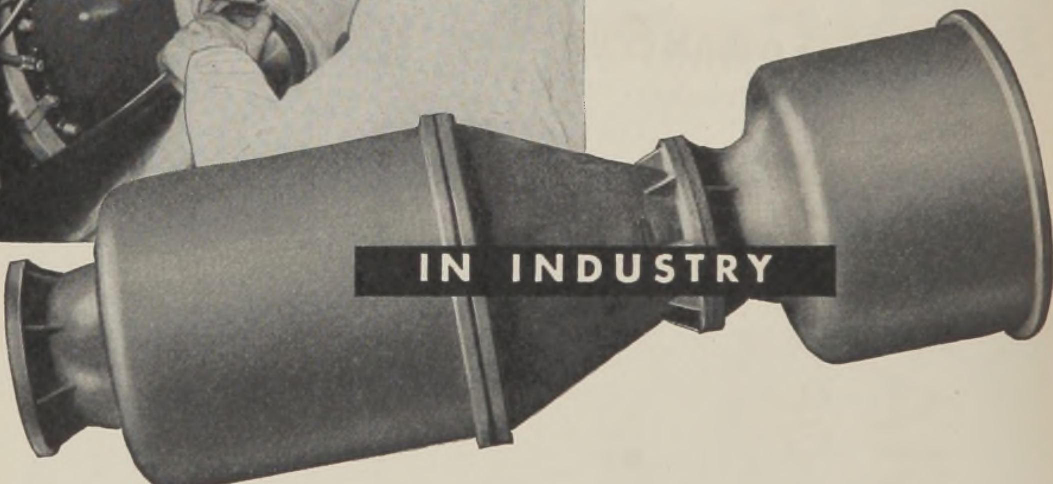


AT THE FRONT — Because of its exceptional ability to resist vibration, annealed Everdur* 1010 Tubing is being used in fast flying Navy planes for vital fuel lines and high-pressure hydraulic systems. *Registered in U.S. Patent Office

IN INDUSTRY—In this cast Everdur drum, dilute sulphuric acid from a pickling bath is rinsed from brass components for cartridges . . . Everdur is ideally suited to this corrosive work.



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Plant Operation:

Sewage Research:

The Operator's Corner:

Editorial:

Proceedings of Local Associations:

Federation Affairs:

Reviews and Abstracts:

Plant Operation

A SEWERAGE PROJECT DESIGNED WITHOUT CRITICAL MATERIALS *

By Paul E. Langdon

Greeley and Hansen, Chicago, Ill.

It hardly seems necessary to make the general statement that some materials normally used in the construction of a sewerage project are now difficult to obtain and are therefore classified as "critical materials." The war effort, with its many demands on production, requires stupendous quantities of all kinds of materials for the construction of army, navy and maritime facilities and the production of the machines and materiel of war. The twin subjects of "critical materials" and "priorities" are probably more discussed now by engineers than any other problems. The exchange of ideas for avoiding use of critical materials as well as experiences in the procurement of essential items is mutually helpful.

Most of the critical materials are well known although the list has seemed to grow day by day until it now encompasses all but a few of the major metallic construction materials. Steel, of course, is one of the most critical items. In its many forms, including reinforcement, structural shapes, pipe and machinery parts, it has had a growing use in sewerage works and is most difficult to eliminate. Cast iron in pipe, fittings, valves, machinery parts and miscellaneous items is apparently somewhat less critical than steel, although a reasonably good priority is necessary to obtain delivery within a practical time. Copper is scarce and its necessary use in motors, electrical conductors and control devices indicates a reduction in mechanical equipment. Rubber, gate valves, sluice gates, lead, used equipment, forms, repair parts, and machinery of all kinds are some of the other principal items to be avoided.

It would undoubtedly be possible to design and build a sewerage project with no critical materials although in many cases this would not be practical. It is seldom that the topography lends itself to the elimination of pumping of both sewage and sludge, particularly where complete treatment is involved. The question of practical limits of reduction in critical materials is a part of each problem that must be considered in the light of necessity of the project, and obtaining a preference rating for unavoidable equipment and of the overall cost both of construction and operation.

Until the turn of the century many of the sewage treatment plants then existing were built without the use of what we now call "critical

* Presented at the Fifteenth Annual Meeting of New York State Sewage Works Assoc., New York City, January 22, 1943.

material.'' In New England, so-called intermittent sand filtration was in common use. An intermittent sand filter plant was often built in natural material. The sand filter beds were created by removing the top soil to uncover underlying sandy material. The beds were surrounded by low embankments, underdrains were laid anywhere from 3 to 5 feet below the surface, and simple distributing devices were used for delivering sewage onto beds and these were built of vitrified clay pipe, of wood, and sometimes ditches and furrows were used. Manholes were built of brick or local stone. Gates were of the simplest sort. Such plants produced excellent effluents. However, they took up a great deal of room—roughly about an acre and a half per thousand people contributory to the plant, and considerable labor was required to scrape the surface of the filters from time to time for removing clogging material that lodged thereon.

Later, preliminary sedimentation tanks were added built of brick, stone or unreinforced concrete. Aside from the gates, these structures embodied no ''critical material.'' Even the septic tanks used, somewhat later, embodied little ''critical material'' if any.

For small communities, treatment plants embodying intermittent sand filters can still be adopted where conditions are favorable, with fair economy and with good results.

All subsequent development in the art of sewage treatment has been directed toward economy of space, economy of installation and economy of operation required to obtain acceptable effluents under any given local condition. This, in turn, has brought about the highly complex, modern, mechanized sewage treatment plant embodying much ''critical material.''

Along with this elaboration of sewage treatment, it has been found necessary to secure more and more technical supervision of operation, including among operating personnel, civil engineers, mechanical engineers, chemists and biologists.

The war effort with its demands for metals and machine work of all kinds tends to outlaw this modern type of plant. There are some areas, particularly in war work centers, where sewerage projects, including treatment, are necessary for the protection of the health of the troops and war workers. The designer is faced with the problem of conceiving a treatment plant, where such is imperative, with a minimum of critical materials, that will produce the required effluent and not be too costly to build or operate. It is therefore necessary to avoid some of the recent conceptions and revert to pre-mechanized types of units, having in mind that it may be desirable to add mechanical equipment at a later date when materials therefor again become available. How far this should be carried is a matter of judgment for any particular use and depends on many factors such as urgency, permanency, cost, location, treatment required, and many other factors.

There should be some differentiation between permanent and temporary construction both of sewers and treatment plant structures.

Where the project is to serve a permanent population, increased by the war program, it should be designed and built with this in mind so that equipment not now available may be installed at a later date. Where a desirable unit cannot be operated without equipment, a temporary substitute may be built, recognizing the desirability of later replacement. Where the project is definitely temporary in character and its usefulness will end with the war, the entire construction may be temporary, thereby reducing the use of critical materials to a minimum.

Essentially, the parts of a sewerage project are the collecting sewers, the trunk or intercepting sewers, the treatment plant and the outfall to final disposal. A particular project will illustrate some of the methods used to decrease critical materials and in some parts to eliminate them. This project is to serve a permanent population and several new war housing developments in a crowded defense area located on tidal waters. Collecting sewers have been built, the trunk sewers are under construction, it is expected that the outfall will be built in the near future and preliminary designs have been worked out for the plant which will comprise preliminary treatment and chlorination.

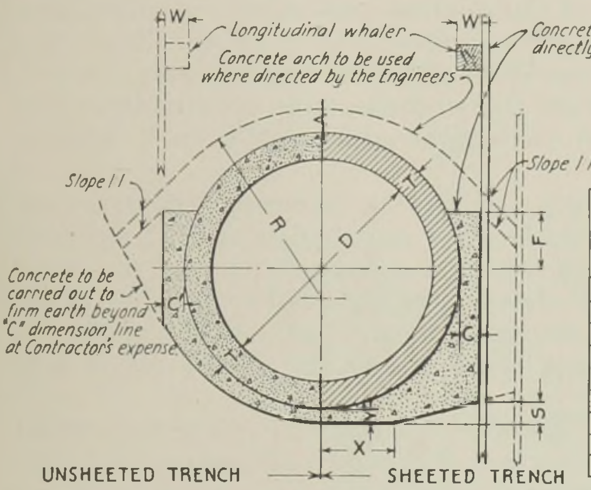

TABLE OF DIMENSIONS FOR TYPICAL CONCRETE CRADLE FOR SEWER PIPE

Diam.	D	39"	36"	33"
Payment Line	F	10"	9"	8"
" "	S	4"	4"	4"
Payment Line for Unsheeted Trench	C' ⊕	5"	5"	5"
Payment Line for Sheeted Trench	• C (Ave)	W+2"	W+2"	W+2"
	A	4"	4"	4"
Payment Line	Y	3"	3"	3"
	T			
Payment Line	X	16"	15"	14"

• (But not over 8")
⊕ C' minimum thickness 5"

FIG. 1.—Typical concrete cradle section for unreinforced concrete pipe.

The size of the trunk sewers required ranged from 36 to 60 inches in diameter. Minimum grades were used throughout to avoid the necessity for an intermediate pumping station. In setting up the design of the sewer sections several alternates were considered and comparative proposals requested from contractors on monolithic concrete construction, unreinforced concrete pipe with a concrete cradle and cradled segmental tile. The contract was awarded and the work is being built using unreinforced concrete pipe for all sizes (Fig. 1). The work has progressed satisfactorily and a sound, tight construction has been obtained.

A special design of a manhole step made of vitrified clay was worked out to reduce the metal required in the sewer construction. The design is relatively simple comprising a formed block with a toe pocket and hand hold. It is bonded in with the brickwork of the manhole, and should prove to be a satisfactory substitute for the conventional cast iron or steel step. Manhole frames and covers were specified to be of precast concrete, reducing the required metal to about 32 pounds for reinforcement from the ordinary weight of cast iron of about 500 pounds. The contractor requested permission to use cast iron frames and covers which he could obtain without extending a priority rating and this permission was given.

There are a few special structures at connections and crossings of existing sewers and drains. In most cases these are built of monolithic concrete and some small quantities of reinforcement were required. The total amount in the entire sewer construction did not exceed 2,500 pounds.

Preliminary investigations of several years past determined the type and scope of sewage treatment for this project, based on pre-war standards. The plant was to comprise sewage pumps, screens, grit chambers, sedimentation and chlorination with separate sludge digestion, dewatering and ultimate disposal as a low grade fertilizer. The plant designed under war conditions and with war limitations on materials and equipment follows these conceptions in structures and provides for adaptation of mechanical equipment when it becomes available.

Although the sewers were designed on minimum grades it was impossible to provide sufficient head for gravity flow through the treatment plant and sewage pumps are a necessary part of the plant. Somewhat more than the minimum pumping head is provided in the pumps to place the structures above ground water level and thereby reduce loads on unreinforced concrete and the weight required to resist flotation.

Sewage pumps, motors, electrical controls and piping are critical materials but no substitute has been found for performing their functions. There are used pumps and motors that can be purchased and reconditioned and this field is to be canvassed fully. Control equipment can be improvised if necessary. In any event the total outlay necessary is small and should not be an insurmountable obstacle.

The housing structure for the pumps is simple and requires no critical material. One design comprises the installation of each pump in a circular dry pit of unreinforced concrete sunk as a caisson (Fig. 2). Independent connections from the trunk sewer to each unit are provided with wood stop gates to isolate the suction, and a wood slat bar screen in another unreinforced caisson type well for protection of the pump. Discharge piping is to have a free discharge into an open conduit leading to following structures. With this arrangement gate and check valves are eliminated on both suction and discharge sides of the pump. The station superstructure is to be built independently of the pump and screen wells on unreinforced footings and with a concrete floor placed directly on the subgrade. The superstructure is of brick and wood construction.

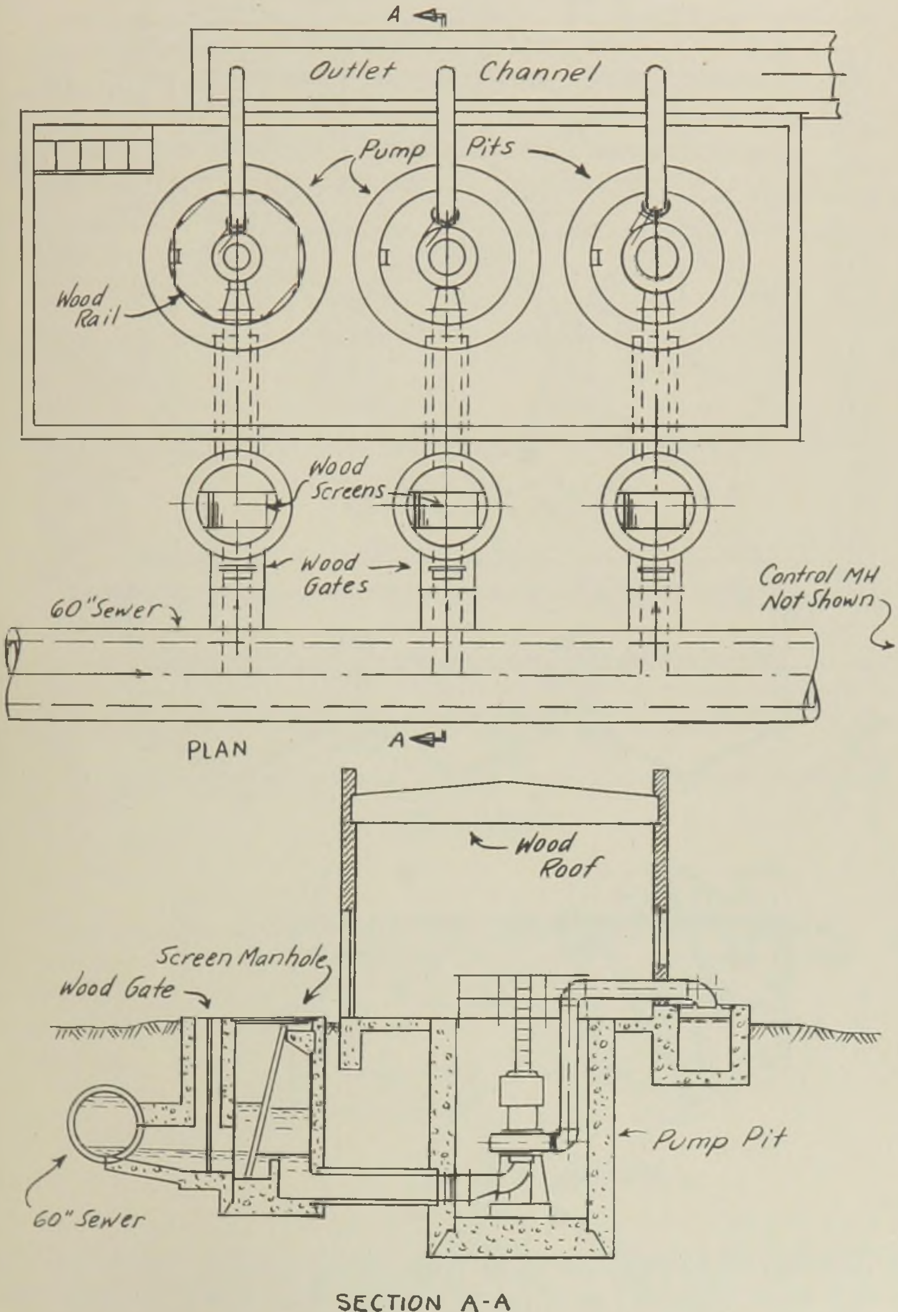

Fig. 2.

Grit chambers are of the conventional controlled velocity type with proportional flow weirs constructed of wood. They are arranged for hand cleaning and are designed of proportions that will allow the later

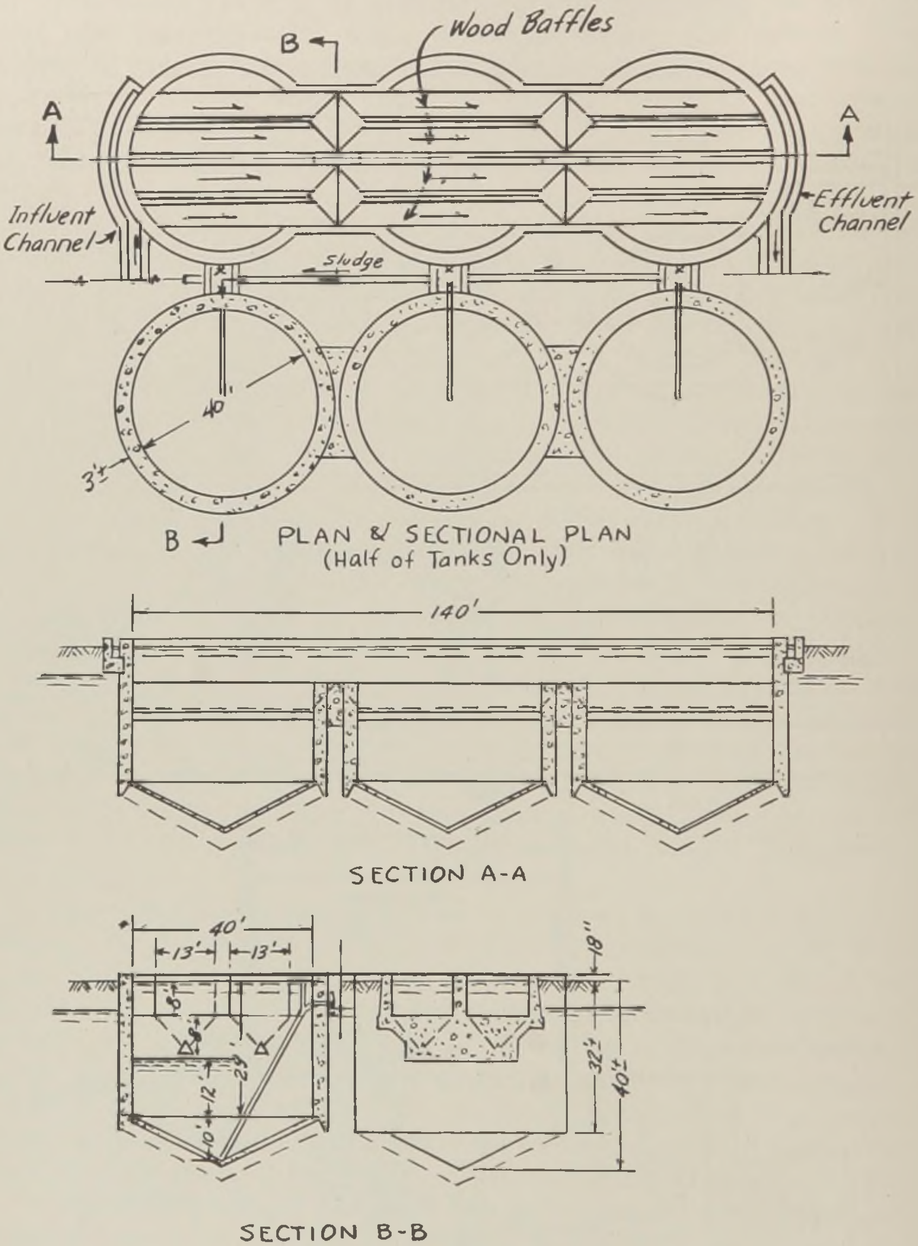

Fig. 3.

installation of mechanical grit removal equipment. Stop logs or wooden sluice gates are provided for inlet control and sluice gates may be substituted later when available.

The entire sewage flow through the plant will be measured by means of a Parshall Flume constructed in the conduit between the grit chamber and the sedimentation tank. If obtainable an automatic recording and integrating meter will be installed, otherwise readings of flow will be logged from a staff gage or simple float.

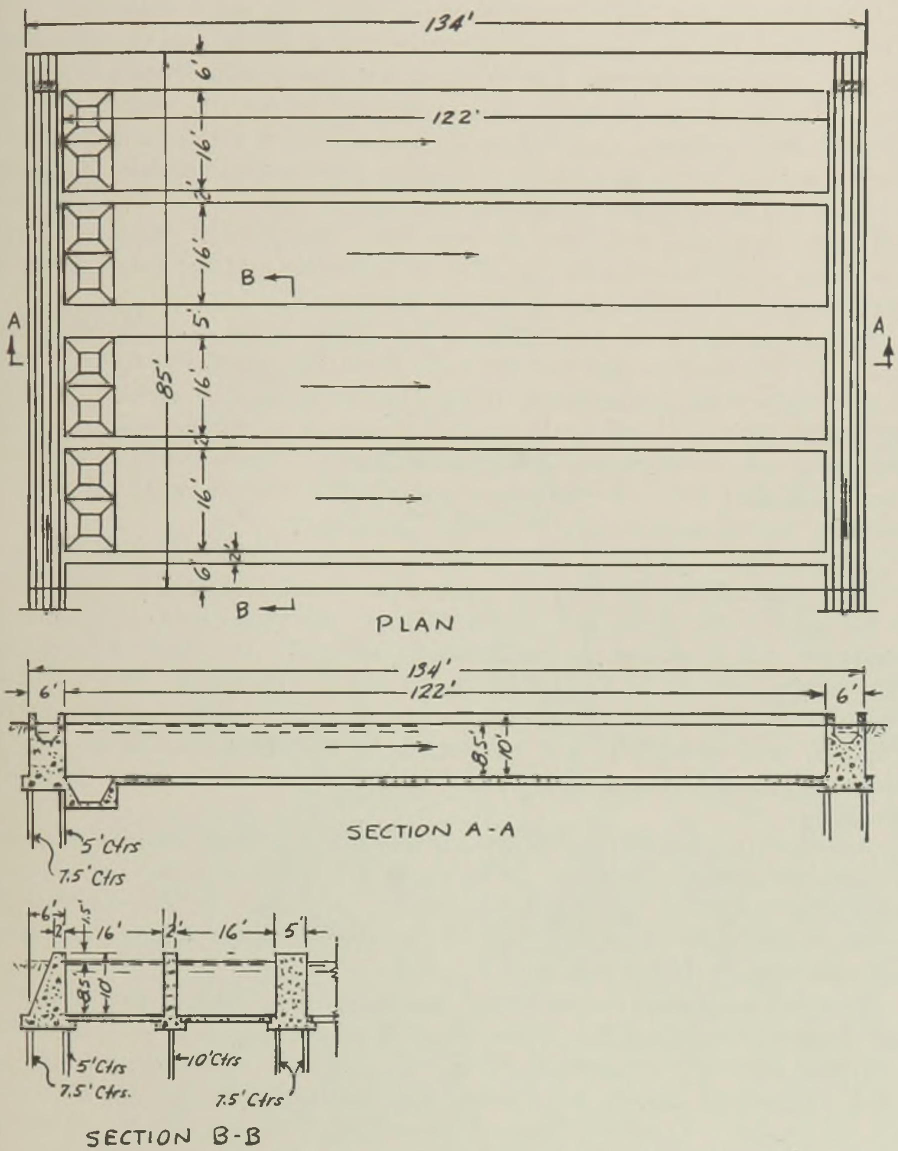

FIG. 4.

The sedimentation tanks presented an interesting problem in the elimination of critical materials. Several alternate types of installations were considered and the choice narrowed to two. One of these (Fig. 3) is of the Imhoff type comprising a series of unreinforced concrete cylinders sunk as caissons with hopper bottoms in each and flowing-through compartments of wood joining the several units. The entire concrete construction would be unreinforced and with wood baffles making up the settling compartments, the only critical materials required would be in the sludge withdrawal piping. The principal objection to this construction is its cost due to the 40-ft. depth of tank and the heavy work required to sink the 40-ft. diameter caisson.

The alternate design is the conventional shallow rectangular tank (Fig. 4) designed for the use of drag scraper sludge removal equipment. In this case reinforcement is eliminated by the use of gravity concrete wall sections and by unreinforced floors which can be above ground water due to the shallow depth. It would be highly desirable to make the installation of sludge removal equipment at the time the tanks are built and this may be possible. Equipment manufacturers have been approached with the idea of reducing critical materials and some progress has been made in this direction.

Sludge pumps will be required for either type of sedimentation tank. In the case of the Imhoff tank they can be of the contractors' trench pump type discharging into a pipe or trough to the sludge drying beds. For the rectangular tanks, piston type pumps will be necessary for pressure discharge to digestion tanks. Here again new equipment designed for the purpose is desirable but reconditioned contractors' trench pumps can be used if necessary.

Round digestion tanks may be built above ground water by using a gravity wall section or may be sunk as a caisson (Fig. 5). The tank at the higher elevation has less heat loss, would be less expensive to construct and is therefore preferable. In order to eliminate heating coils, sludge should be heated by direct steam application prior to discharge into the tank. Floating covers are desirable if they can be obtained and the tanks are arranged to accommodate them. As a temporary expedient a fixed or floating wood cover is a possible alternate.

Another possibility in this case is the temporary use of old wooden barges for sludge digestion. They are available and can be moored along the adjacent bulkhead. It would probably be impractical to maintain desirable temperatures in the sludge under these conditions and somewhat greater capacity would be required.

So much equipment is involved in a mechanical dewatering installation that this method has been abandoned for the duration and conventional drying beds substituted. The design contemplates use of wood exclusively for division posts and planks, runways and distribution of sludge. Their cost is not great and they can be abandoned in favor of the mechanical equipment when it again becomes available.

The outfall sewer will provide ample contact period for sterilization with chlorine and a tank for this purpose will not be necessary. Liquid chlorine in solution will be applied to the tank effluent through conventional equipment, if it can be obtained, or may be applied as a solution of calcium hypochlorite by means of one or more constant feed orifices of proper size to adjust the dosage to the rate of sewage flow.

An outfall sewer of 48-in. diameter extending 1,700 ft. into tidal waters with a depth of 33 ft. at the outlet requires careful consideration of construction conditions and procedures. Steel or reinforced concrete pipe are both recognized as suitable materials for such sub-

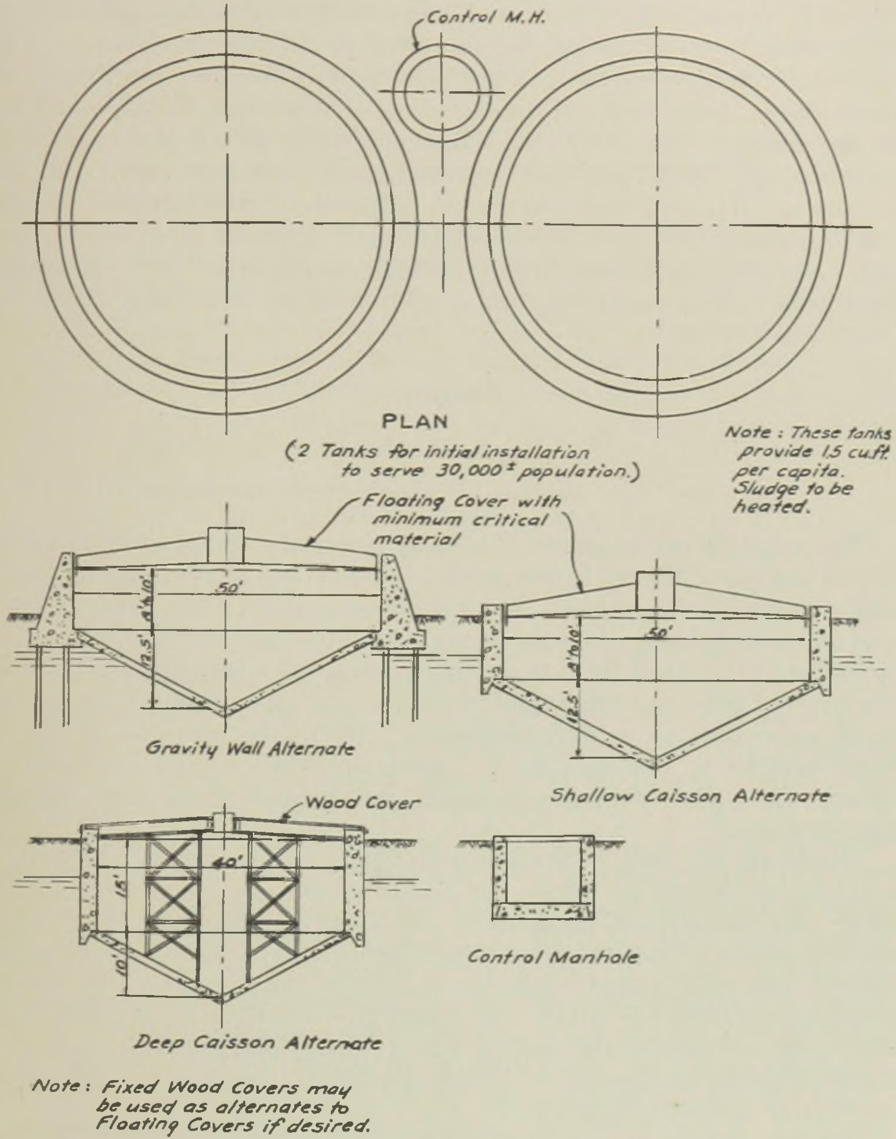

FIG. 5.

aqueous construction. Concrete pipe was selected for this installation, reinforced with a single elliptical cage of steel. The total weight of steel in the entire length, including joint rings, reinforcement, harness bolts and fittings and anchorage at the outlet end is less than 40 tons.

The design at the outlet will provide wide dispersion and makes use of noncritical materials to provide security for this vulnerable section of the structure.

Some of the methods used or suggested for elimination or reduction of critical materials are only minor deviations from accepted modern practice. Some others represent more radical departures and might, under other circumstances, be classified as "flight of fancy." They are not recommended for general adoption as in some cases they will result in increased costs of construction or operation or both, and may require a longer time to build. However, when a necessary plant must be built and limitations are imposed as to available materials and equipment, the challenge cannot be ignored. "Strongarm" methods must be employed under such conditions. A great deal can be done with available materials by the proper application of fundamental principals. It is surprising, in a way, to what a limited extent this effort is often made.

Discussion

By A. M. Rawn

Chief Engineer and Manager, Los Angeles County Sanitation District

The administrative officer of a large sewerage authority works today among many conflicting forces, and it becomes his job to balance them in such a manner as to keep his house in order and his plant properly operated and maintained. It is the general rule that the revenues with which he works are derived from taxation in one form or another and that for any current year his budget and requirements have probably been anticipated some year or more in advance. Unless there are other and unusual sources of revenue, he is limited by what he has on hand and cannot, in many instances, expand his resources to meet unusual requirements.

Generally the policy-determining agency of a sewerage authority is a governing board to whom the administrator is responsible for the safety and integrity of the system. It is especially important at a time like the present that there be a thoroughly sympathetic understanding between the administrator and his legislative board, and to this end the former must bend his effort. The board is usually charged with determining the amount of the annual levy and the administrator encounters added difficulty in having to justify additional costs in the face of restricted or impaired service.

Health authorities, in view of the limitations imposed by Federal regulations, have relaxed their requirements to some extent but not their vigilance. Although their ranks of technically trained men have been seriously depleted those who remain appear to be equal to the occasion and public health will probably not suffer greatly. Indeed, it is not unlikely that the present situation may disclose a surprising sense of responsibility in local authorities.

The administrator must deal with a large group of Federal agencies imposing sweeping and rapidly changing regulations regarding what the nation as a whole may or may not do in the way of operation, maintenance, repairs and extensions. These regulations, many times inapplicable to the large sewerage project, must, nevertheless, be observed. They are certainly not aimed at simplifying one's job. In fact, the reverse is quite universally true and must necessarily be so in view of restricted materials and manpower. The observance of governmental regulations is an added duty to seriously impaired organizations and one which requires intensive study as well as a material amount of work within an organization to effect compliance with rapidly changing conditions and orders.

In complying with current Federal orders it is many times necessary to indulge in some weird adventures in designing and to invent new and unusual patterns of procedure. This feature alone contrives to leave little, if any, leisure or complacency in the office engineering staff. The building of structures without materials now deemed critical and which seemingly yesterday were identified as entirely essential, is a task which leads engineering design forces through unfamiliar paths before the proper objective is reached. It most certainly is not conducive to minimizing the task of administration.

Until the end of the war, when sanitary engineers presently of military age return to their civilian pursuits, it appears unlikely that depleted technical staffs are going to be built up with the younger personnel so essential to their growth and development. Sanitary engineers are even now being placed under the same regulations as to assignment that obtain in the case of doctors, dentists, etc. A number of technical men will be released from employment in 1943 because of a rapid cessation in building construction; but if they are of military age and otherwise acceptable, they will doubtless go into the armed forces so that about all one can hope for is to staff with older men.

The most perplexing problem of all is manpwer. This difficulty manifests itself first in actual shortage of sufficient personnel to do the job properly; particularly if one desires to adhere to a work-week established by law and based upon 40 hours of labor in 7 days; and second, in the difficulty of persuading men to continue working for pre-war wages when government and industry, and all others working in the national defense program, are competing with one another and with lower levels of government, by paying the highest wages the country has ever known. As heretofore stated, it is not always possible to find the means wherewith to raise salaries when operating on a fixed budget, especially when the situation has developed with the rapidity characteristic of the one with which we are now faced. The difficulty is not insurmountable, however, if the staff can be persuaded to work longer hours, in which case the salaries in unfilled positions may be divided among those who have to assume new duties and work longer hours. This policy is being followed with some success in a number of large organizations.

The picture is not black—just a little foggy. Probably no worse in sewerage problems than in any other local governmental function, and one finds among the Federal agencies some pretty good friends who are willing to extend their efforts to help those in distress. Among these are the Federal Works Agency, administering the funds appropriated under the Lanham Act, for the construction of public facilities where war industries have necessitated their installation and where they do not otherwise exist and cannot be provided by local governmental agencies; another, the Defense Plant Corporation, seemingly always willing to carry its full share of the load in adapting existing sewerage facilities to its needs; and still another, is the Army, via U. S. E. D., which has been more than fair in its dealings with those local agencies serving the Army's needs.

As might be expected, the national emergency has not tended to ease up on the duties of the sewerage administrator, but conversely, has materially increased his labors and difficulties. Nevertheless, from what may be learned, sewerage systems are not being seriously impaired nor will they feel greatly the effect of war unless the emergency continues over an extended period of years.

FORUM: INFLUENCE OF THE WAR ON SANITARY ENGINEERING *

Leader: LINN H. ENSLOW

PARTICIPANTS

CHARLES A. HOLMQUIST, New York
(State Engineer)

CHARLES GILMAN HYDE, California
(Educator)

WILLIAM M. PIATT, North Carolina
(Designer)

GEORGE J. SCHROEPFER, Minnesota
(Operator)

Introductory Remarks

BY LINN H. ENSLOW

Editor, Water Works and Sewerage and Chairman, Sanitary Engineering Division, A.S.C.E.

Chairman Velzy, Members and Honored Guests: The speaker considers it a privilege and honor to have been asked to preside over this Forum on the timely topic of the influence of the war on sanitary engineering, as a profession and practice in the recent past, the present and near future. It will be noted that this topic is in effect continued at the Annual Division Session this evening by Dr. Abel Wolman, to whom the speaker feels particularly indebted for having accepted the urgent invitation to address us on the especially timely topic of the place which the sanitary engineer and sanitary engineering was to occupy in the post-war world. From my conversation with Mr. Wolman those not present here shall miss a great deal of information which the sanitary engineer should wish to have concerning the future of this branch of the engineering profession—and the term sanitary engineer is here used in the broad sense to represent water and sewage works managers and operators, in addition to public health engineers and designers.

It is a genuine pleasure to be able to say to you that every single one of these distinguished speakers from whom you will hear has responded one hundred per cent to the request of your Committee on Arrangements to take part in this special Luncheon Forum. I should say to you that Secretary Bedell, in extending the invitation, used a method of the day when he informed each participant that he had been chosen with thought and a purpose and that each should consider that he had been "drafted"

* Presented at The Fifteenth Annual Meeting of The New York State Sewage Works Association, New York City, January 22, 1943.

for the occasion. Like the soldiers that they are, each of them took on his assignment without a single plea for "deferment" coming from any. Your Committee and the speaker feel that you have a real treat coming to you in hearing from such a representative group as you see sitting at this table.

You will note that the cross-section includes an outstanding State Sanitary Engineer—Chas. A. Holmquist—whom this Association has too infrequently had the privilege of hearing. His Division in the N. Y. State Department of Health has done an outstanding job of serving the war effort. In fact his Principal Assistant Engineer—Earl A. Devendorf—as State Water Coordinator has just been voted the Diven Medal by the Am. Water Works Association for the splendid job done in the Mutual Aid Program which has been so thoroughly developed in N. Y. State and its effectiveness proven by several tests. We are especially pleased with our success in getting Charlie Holmquist to appear on this program even for the five minutes that the several speakers were requested to fill.

The next speaker in recent years has become a "regular" in attending sessions of the N. Y. State Sewage Works Association after a hard week of activities on the A.S.C.E. Board of Direction and several of its hardest working committees. As Chairman of A.S.C.E.'s Committee on the Advancement of Sanitary Engineering for several years he has filed a noteworthy report of this important committee which is now in print. In his capacity as Professor of Sanitary Engineering at the University of California he will review the effects of this war on sanitary engineering training and preparation from the standpoint of "The Educator."

Before leaving this participant, whose five minutes will pass I predict far too quickly to please this audience, I wish you to know that he was honored by the student body of U. of C. by being elected "Dean of Men" —no little distinction I can assure you—but, knowing Charlie Hyde is to appreciate why.

The third participant has become a "regular" at these annual meetings also. We have never before been able to get him on a program. He is presented to give the problems and the effects of this war on the "Plant Designer." He can review this topic not alone from this war but also from World War I. He is a Pennsylvanian (Lehigh) who transplanted himself to North Carolina long ago and the tar gathered on his heels in the first year of his residence has been effective in holding him in his adopted state these many years. If he tells you one-tenth of what he could of the problems of the designing engineer in charge of cantonment construction and the building of sanitary facilities during World War II, I will be surprised —the afternoon isn't long enough. Whatever he has to tell, I know that you will be repaid for having brought to you this capable designer and old "War Horse"—"Bill" Piatt of Durham, N. C.

The fourth participant will speak from experiences of the "Plant Operator"—and, here again, five minutes is not enough. Anyone who has in recent times visited the Sewage Treatment Works of Minneapolis and St. Paul, which he manages, will have been impressed with plant maintenance and operation plus salvage of critical materials and a wartime economy throughout. This participant, who has completed evaluation of a splendid and rapidly consummated survey of the normal requirements of critical materials for sewer system and sewage treatment plant maintenance and operation, is serving as Consultant to the WPB in Washington. I hardly think that George Schroepfer, President of the Federation of Sewage Works Associations, requires any further introduction to this group.

The fifth participant will review some of the "headaches" that this war has brought to the Chief Engineer and Manager of a county-wide Sanitation District—or Districts is a more proper term perhaps. He will impress on you that most of these "headaches" have a remedy if one appreciates the proper source to go to and proper procedure to follow in seeking alleviation, even though complete "cure" may not be had. He will tell you, I believe, of the effects of the ravages on key operating manpower and some measures at the manager's disposal to check this "headache," which is amongst the most severe. It is a privilege to hear from the Sewage Federation's Vice-President, who besides managing the Sanitation Districts serving 26 municipalities in Los Angeles County finds time for sitting in the quarterly meetings of the Board of Direction of the A.S.C.E., performing magazine editorial functions, serving as County Decontamination Officer, etc., etc. He is our stalwart from Southern California—A. M. Rawn—known far and wide as "A.M."

†Charles A. Holmquist:

I shall limit my discussion of this topic to the point of view of the state departments or boards of health. In order to determine the influence of the war upon the sanitary engineering activities of state health departments a questionnaire was sent out by a Committee on Defense Sanitation of the Conference of State Sanitary Engineers last year. Replies received as of September 15, 1942, indicated that the war has had serious impact on most of the state sanitary or public health engineering organizations. Most state health departments had lost a large proportion of their engineering personnel at a time when the duties imposed upon them had increased greatly as a result of the war. Some states had lost 50 per cent or more of the personnel, about two-thirds of whom had entered military service and about one-third had resigned to take more remunerative civilian positions in war-connected industries.

In many states the depletion of sanitary engineers seems to have gone beyond the point where adequate service can be rendered and further losses would seriously handicap the public health engineering work in such states. The difficulty of getting replacements is indicated by the fact that with a total of 366 engineers or sanitarians lost, only 48, or about 13 per cent, had been replaced. Only five states reported no loss in engineering personnel but they included those having only one sanitary engineer, the chief engineer or director of the division of sanitary engineering. The conditions have been alleviated somewhat, however, by the employment of engineers loaned to various states by the United States Public Health Service. Only five states reported they had been able to carry on routine work as before the war.

† *Director, Division of Sanitation, New York State Department of Health, Albany, N. Y.*

Our experience in New York State has been similar to that of the other state departments of health. Out of our total of 49 engineers we have lost 15, of whom 7 were in key positions in the Central Office or in charge of our District Offices. They are all commissioned officers in the army or navy. Six replacements have been made by the appointment of new men of less experience. There are now 9 vacancies that we have been unable to fill with qualified engineers. Our inability to fill vacancies is due not only to the lack of available qualified sanitary engineers but also to the fact that when the permanent incumbents on military leave return the substitute appointees will lose their positions in accordance with the provisions of the Military Law of New York State.

Even under normal conditions the loss of so many engineers would have handicapped the work of the Division considerably but, coupled with the large number of added duties imposed upon us by the war, it has become a problem of major magnitude. In addition to the Mutual Aid Program for Water Service, which has occupied nearly half of the time not only of the Central Office staff but also of the field staff, the following are among the more important time-consuming additional functions that have been assumed by the Division as a result of the war:

(1) Studies of industrial waste problems in connection with munition and industrial plants.

(2) The examination of and passing upon plans for water supply, sewage and waste disposal for war industries, military and naval establishments and housing projects.

(3) Giving advice and assistance to military authorities on sanitary engineering problems.

(4) Assisting in the sterilization of new water mains installed to serve war industries and military establishments.

(5) Engagement in sanitation activities in connection with expanded and new war industries and housing projects.

(6) Survey of important war-connected water supplies with reference to their protection against possible sabotage, carried out under the Facility Security Program of the United States Public Health Service. These surveys, which consumed about 140 man days, were made by our district engineers with the cooperation of the State Police.

(7) Investigating projects submitted under the Lanham Act including conferences with municipal officials and the examining and passing on plans for such projects.

(8) Keeping the State War Council advised of the activities of the Division on war connected problems.

(9) The control of sanitation around military and naval establishments during and after construction. This work has comprised milk control, restaurant sanitation, supervision over water supplies, sewerage, waste disposal, etc.

In connection with the construction of a large ordnance depot there was an influx, without warning, of several thousand employees into a rural area consisting mostly of sub-marginal farm land and a few hamlets having neither public water supplies nor sewerage systems. It was necessary for our district staff to take over the entire control of sanitation in the area.

Arrangements had to be made by our engineers to distribute water in tank wagons, to build privies, to examine and post hundreds of farm wells that were available to employees both inside and outside of the reservation, to supervise and establish trailer camps, etc. Six engineers, including two U. S. Public Health Service engineers, were employed on this work for about six months, working many hours overtime. Although the stage was set for serious outbreaks of communicable diseases due to lack of water supply and sewerage facilities and the deplorable conditions resulting therefrom, it was gratifying that not a single epidemic occurred in this area. Credit for this must be given to the field staff for its prompt and efficient work.

As a result of these new activities brought about by the war it has been necessary to curtail many important functions of the Division, such as routine supervision over the operation of water and sewage treatment plants. We have had to depend on the monthly reports of daily operating results submitted by the operators to determine if the plants are being operated satisfactorily and to make inspections only at the request of the operator or when the monthly reports indicate that difficulty is experienced. Until the war is over it will not be possible to exercise more detailed supervision over these and other public health services in the state.

*Charles Gilman Hyde:

I have been asked to present my opinion with respect to the influence of the war upon sanitary engineering. Opinions are based upon impressions. Impressions are derived from reading and observation. To quote Will Rogers: "All I know is what I read in the papers." And to this, in the present case, I will add the results of such observations as I have been able to make on the far western fringe of this country.

In general it seems to me that the influence upon sanitary engineering of this war, both currently and in the post-war period, is and will be salutary. However, there are or may be certain elements of danger. These are related to the efficiency with which sanitary engineers, or those who claim to be such, perform their allotted tasks. There can be little question concerning the quality of the performance of those who are truly competent by reason of training or experience, preferably both. The real danger lies in the behavior and output of those who are not competent, yet who have been placed in a position to undertake sanitary engineering work and responsibilities by virtue of the great pressure or demand for such personnel.

In the first place this war, as no other war and no other period in the world's history, has created a demand for the sanitary engineer's services. This demand obtains with respect to our armed forces and to civilian duties appurtenant to the war effort.

Large numbers of sanitary engineers have been commissioned in the Sanitary Corps of the Army. And now, for the first time in our history, sanitary engineers are being sought in connection with the far-flung activi-

* *Professor of Sanitary Engineering, University of California, Berkeley, Cal.*

ties of the Navy and Marine Corps in the present struggle and for the post-war era.

The sanitary engineering personnel of the United States Public Health Service is being largely expanded, both as commissioned officers and as civilians. For the most part such men are required to have special training in problems of environmental sanitation.

The construction of great numbers of army cantonments, camps and posts, and the assignment of the operation of their utilities to the Engineer Corps, has for the first time called into service in that arm sanitary engineers, as such, both commissioned officers and civilians. This personnel is engaged upon the design of works and upon operation.

In the design of the utilities for the Army, Navy and Marine Corps, and to a less extent in their construction, designing engineers and contractors have employed many men with at least some training and experience in the sanitary engineering field.

The conditions of the post-war period will doubtless demand that a vast program of sanitation be conducted in order to keep people at work until industry and other activities absorb the then available surplus of manpower. The planning, design and construction of such public works will enlist the efforts of many sanitary engineers now in civilian life as well as those released from direct war service. Moreover, it is probable that our Army and Navy will continue to utilize the services of some of their sanitary engineering personnel, at home and abroad, for years to come. If America is to play its proper role of a "brother's keeper," foreign service in the field of sanitary engineering may be expected to be extensive and prolonged.

It is to be hoped that the impact of the war upon sanitary engineering will reach back to our educational institutions and their curricula. The Report of the Committee on the Advancement of Sanitary Engineering of the Sanitary Engineering Division, American Society of Civil Engineers, has strongly emphasized the fact that many of our engineering schools are graduating men who are dubbed "sanitary engineers," but who have had but little exposure, if any, to fundamental courses in bacteriology, sanitary chemistry, and, in general, to those dealing with the broad field of environmental sanitation. Since the demands of this war are demonstrating as never before the value of this better sort of training, it is to be hoped that our schools will respond and will revise their curricula accordingly. Otherwise, that training, undergraduate and graduate, should be delegated to those institutions only which can offer competent instruction.

Another effect of this war upon sanitary engineering—but this may be wishful thinking—lies or should lie in the planning and construction of simple or simpler works where simple procedures and treatments may properly be employed, thus capitalizing natural features and conditions to their rational limit.

Still another effect relates to the discovery that many non-critical materials can profitably be employed where in the past less abundant and more costly materials have been used. This same situation may apply to methods and procedures, as for example, in the use of protective coatings or other devices for the preservation of certain more vulnerable but less expensive materials.

In summary, it would seem that sanitary engineering is in a uniquely favorable position both during the active prosecution of this war and under the probable conditions of the peace which will ensue. This favored status would appear to comprehend a better appreciation of the sanitary engineer and of his achievements, actual and potential; a much greater demand for his services; and, it is to be hoped, a broader and more competent fundamental education, in order that his title may be justly applied and held.

*William M. Piatt:

Mr. Chairman and Fellow-Sufferers:

For some ten or fifteen years I have looked upon the third week in January as my annual vacation, and I have been happy each time to return to the struggle at home wondering all the time if I could make it again the next year. And, in spite of the fact that I have never been a member of this organization, the high light of the week has been your meeting and its opportunity for close association with the most unselfish body of men in the world, who devote their every waking moment not to gold digging, but to public service.

All of these years I have been applauding from the sidelines. This year my sins have caught up with me and I have been drafted to tell you in five minutes what I think the war had done for sanitary engineering. I have no Army background. I was a college student during the Spanish-American war, a father with six children during World War I, and for many days I have thought diligently but hopelessly of something to say on this subject. Then the thought came to me that something was wrong with the picture, that what sanitation and science have done for the Army was nearer the truth, and so I am changing my text.

In our own wars disease has killed more soldiers than bullets have. In this city of New York during the Revolutionary War smallpox broke out and two of my ancestors who were prisoners in a British prison died as a result.

Compulsory vaccination has made us all immune to that terrible scourge.

At Salisbury, in North Carolina, 11,700 Union soldiers are buried in 18 trenches, nameless and unknown, as a result of insanitary conditions in the prison there during the Civil War.

In the early nineties the Ninth Regiment was the crack regiment of the old National Guard in Pennsylvania, and rumor had it that this regiment was to be sent to the Columbian Exposition. The regiment was recruited to full strength overnight, and then the steel strike and riots sent them to Homestead to sleep in tents in the dead of winter, but there were no flies or mosquitoes to spread disease, and they didn't get to Chicago.

Five years later this same regiment in a tent camp in Florida was almost wiped out by typhoid fever and never got to Cuba.

* *Consulting Engineer, Durham, No. Carolina.*

The French Company that tried to build the Panama Canal failed because of yellow fever and malaria, but the Army engineers built it for us after science and sanitation had eradicated the mosquito.

Then we were plunged into the World War in a terrible winter with measles and influenza rampant both in the partly built army camps and in our cities and towns as well, and the death toll from disease was enormous.

And now we are in a Total World War, a totally different war, that we couldn't possibly get into, and our soldiers are being trained in clean camps, housed in substantial, heated buildings, with screened openings, safe water supplies, garbage incinerators, sanitary plumbing, and water-carried sewage, with modern disposal plants, and wonderful hospitals. When our soldiers take the field they have been immunized by inoculation and vaccination against many of the known epidemic diseases and drugs are available for the cure of most of the rest, and so we have the feeling that from the record as it stands today, surely science and sanitation, with discipline, have made the Army a safer refuge for the soldier up to the time he goes on the firing line than we who are in the background enjoy in our own homes and towns. The soldier's greatest danger today is a furlough.

*George J. Schroepfer:

In a desire to do his part in the early winning of the war, the operator of sanitary facilities has met and satisfactorily solved a number of perplexing problems, which at the time they presented themselves may have seemed almost insuperable. Some of these could be anticipated and planned. Some arose suddenly and without warning, and some were thrust upon him without his having a voice in their handling or any control over their effects. He has taken them in stride with the feeling ever present that in their solution he was making a direct contribution. Oftentimes he realized that in the solution evolved, advances had been made in the art which will be of lasting benefit to the profession.

Some of the effects of war with which the operator has been confronted are the following:

1. As a problem the loss in trained personnel has been a vital one and is increasing in seriousness. In some of the recently constructed mechanical plants the loss of one-fourth to one-half of the regular personnel presents a problem of considerable magnitude. In this connection the work of the Federation in securing recognition by the War Manpower Commission of the essential nature of our field as a public health service, is worthy of mention.

2. Many plants have been confronted with the problem of handling additional quantities of sewage and industrial wastes in plants already taxed to the limit. This has resulted from increased industrial wastes from war plants, in the treatment of which many unusual and troublesome problems ensue, and from the shifting of population to centers of war

Chief Engineer and Superintendent, Minneapolis-St. Paul Sanitary District, and President, Federation of Sewage Works Associations.

activity. In some cases concessions have had to be made to stream cleanliness, which should be recognized by public authorities as being temporary duration measures.

3. The scarcity and the difficulty of procuring certain critical materials is a real problem to the operator, both from the standpoint of maintenance and repair, and from the difficulty of making needed additions and improvement changes. The fact that the W.P.B. has recognized the vital nature of our field by granting priorities, which on the whole have been fairly adequate, has assisted us immeasurably.

4. To the above can be added a multitude of other problems and minor inconveniences of local application, which result from the war and which the operator charges on his mental books to H. & H., knowing that in the final accounting satisfactory repayment in full will be had.

So much for the headaches. It is much more pleasant and constructive to think about some of the things the operator can do to assist in bringing this conflict to an early conclusion. The operator has learned to reduce the use of critical materials in order to make them available for direct war use. He can reduce further. He has learned to improvise. Now it is necessary to improvise on the improvisations. He has learned the need for increased use of his products such as fertilizer, grease, and gas. He can promote their further use. He has effected economies and secured increased capacity or efficiency out of his processes. Possibly he can squeeze out just a bit more. In all of these ways and more, the operator can do his part, and it is no small one, in contributing to an early victory.

Our forward-looking officials are already making plans for winning the peace. We have some plans of our own that need formulation. Thought on the many changes and adjustments in returning to our normal operating conditions should not await the time they are upon us. We should think of methods of insuring the return of operators and personnel to their former positions. We should think of increasing the recognition to and the standards of plant operators. We should plan improvement changes which have been deferred, and needed additions which have been suspended, so that when the war is won and the call for projects goes out our field will share in the benefits and continue on the upward trend so marked before the war.

Much of the effort in this direction is for the individual. However, certain of these problems are of a type towards which as individuals we can accomplish little and which therefore must be attacked by group action. As I prepared these notes on what is needed I realized at several points that the Federation and the various member Associations have already moved in that direction. Speaking of the Federation, committees have been active on just such projects as have been enumerated. We have very active committees working on such matters as Post War Planning, War Service, Operators' Qualifications, and Publicity and Public Relations, just to mention a few. Many more service possibilities are open to us and while much has been done a big job remains. We too are winning our battle.

WARTIME SANITARY PROBLEMS OF A STATE HEALTH DEPARTMENT *

By W. F. Shephard

Assistant Sanitary Engineer, Michigan Department of Health, Lansing, Michigan

Our introduction to the problem of wartime sanitation came in August, 1940, when preliminary plans for reconstructing the sewage treatment facilities for Selfridge Field came to us for review. The uncertainties encountered in the preliminary phases of this project apparently formed the pattern for subsequent projects. Estimated loadings fluctuated from week to week over ranges of several hundred per cent before a final decision was made and construction undertaken. Although we did not then realize it, that was just the beginning of a series, the end of which we have not yet seen.

Hardly had the Selfridge Field problem been decided, when we received word that someone was to construct a huge factory for the construction of tanks. Presumably there existed good reasons for the choice of the site selected for this factory but certainly availability of adequate sanitary facilities was not among them, for it was located in a highly vulnerable point in Michigan's sanitation front. Again we went through a series of guesses as to the number of employees that would be needed and further guesses as to the nature and volume of wastes.

Sanitary problems in this region were not new to us, by any means. Extensive litigation over its drainage structures, built by the only existing authority in response to urgent demands, had finally ended in 1931 in a decree by the Michigan Supreme Court holding the proceedings by which these structures had been built to be "null and void and of no effect whatsoever." The learned court failed to explain just how to go about ignoring a 10 or 11 ft. diameter sewer serving some 10,000 people and a drainage area of some 11 square miles.

For ten years we had struggled with this area trying to work out some plan of financial and sanitation salvation. Tax delinquencies rose to over 80 per cent, and bonded indebtedness even now in some districts approaches 59 per cent of the valuation. And then into the midst of this came the "defense industries" and with them the problems of caring for their thousands of employees and their families. The district, utterly destitute, bankrupt and without resources of its own, simply could not carry such a load. Fortunately during the preceding ten years a great deal of thought had been given to the problem, and a specific plan of solution was available. The authorities in Washington had sensed the difficulties which the construction of rearmament plants might bring to local communities and had decided that assistance was necessary. Soon the Federal Works Agency, Defense Public Works Division, was set up

* Presented at the Third Annual Convention of the Federation of Sewage Works Associations, Cleveland, Ohio, October 22, 1942.

and a regional office for the states of Ohio, Kentucky and Michigan established in Detroit to administer this activity.

All sorts of schemes were offered and suggestions considered for solving the Macomb County sewerage problem. Briefly stated, the problem was to extend lateral and sub-trunk sewers to the areas within and without the five incorporated cities and villages in the southern portion of the county where need existed and where it was likely to develop, and then to convey that sewage to a point of disposal in such a manner as to properly protect Lake St. Clair, which is the source of water supply for the greater part of the Detroit metropolitan area, and which is also widely used for recreation purposes. As finally adopted, the major plan was composed of severa projects. Lateral sewer projects were filed by individual municipalities and the township of Warren, and a project for an interceptor designed to collect the sewage and deliver it to the Detroit system for treatment was filed by the two counties, Macomb and Wayne.

In order to satisfy the requirements of the various legal and financial authorities involved it was necessary to secure passage of certain enabling acts by the State Legislature. Then it was necessary to formulate and later secure individual acceptance of the proposed contractual relationship provided for in the enabling act by some nine township, city, and village governments as well as the Board of Supervisors of the two counties involved.

The appropriate projects were finally prepared and the applications duly filed in proper form and number with the Defense Public Works Division of the Federal Works Agency. After several months, word came that the group of applications from Macomb County had received presidential approval and that an allocation of funds had been made. Lateral sewer projects for Warren township, a sewer to a Federal Public Housing project, some lateral sewers in Center Line, all contingent, by the prescribed terms of the allocation, upon the construction of the interceptor, were finally released and put under contract. Early in 1942 bids were received but no contract awarded because the bids had exceeded the estimates. Only this month—October, 1942—has the contract for this project, greatly reduced in scope and in effectiveness, finally been negotiated some 20 months after the current study was begun.

Immediately west of Macomb County lies Oakland County. Its story and its problem is very like that of Macomb. Its net progress toward solution of a similar problem in the same length of time is a few stages short of Macomb. It is now held up pending an election November third.

About a year ago the Ford Motor Company selected Ypsilanti township, about 30 miles west of Detroit, as the site for their "Airplane Parts Manufacturing Company"—the famous Ford Willow Run plant.

From a sanitary aspect, we began with an estimated employment figure of thirty thousand, but it was finally determined to provide for two shifts of thirty thousand each. The sewers for this job are built and the activated sludge sewage treatment facilities have been operating for ten months. It is interesting to observe that in addition to a plant for treating domestic sewage, the management has provided facilities for treating industrial wastes created in the plant.

Less spectacular than those instances sighted, but none the less providing a real problem was the working out of the sewerage problem for the Fisher Body plant south of Flint. This was a wholly new enterprise devoted entirely to war production. The only watercourse immediately available for carrying off a plant effluent was a very small stream that flows through a well developed portion of the City of Flint. It appeared likely from the characteristics of the stream that anything less than complete treatment would create a nuisance and even with such treatment a real difficulty with algae growths could be anticipated. The management became interested in a proposal to construct a connecting sewer from the site of the factory to the nearest sewer of the City of Flint. A study of the possibilities of such a proposal resulted in its adoption and with the cooperation of the officials of that city, is now in operation. This plan provided a better solution at lower cost, sooner, and with a real saving of critical materials.

A somewhat similar solution was worked out for an industrial plant at Muskegon where, after a little study and negotiation, a plan was evolved making such a connection possible.

An interesting problem for our Stream Control Commission as well as ourselves was created by the expansion of one of our industries engaged in the manufacture of magnesium. The process involves pumping of a high magnesium brine from the ground and processing it to produce the metal. Large quantities of electrical power are required. Unfortunately the best brine is located at a place where power is not now available in sufficient quantity. It was decided to split the process, carrying on certain portions of the process at the location of the brine, and shipping the partially processed magnesium to another factory where power is available. At the first location it was necessary to work out a plan of disposal for large quantities of brine and in the second location large quantities of strong acid. Fortunately the water resources are such in each case as to make it possible to dispose of these wastes, at least for the duration, without appreciable damage. It is necessary in the first instance to transport the brine to a point of disposal several miles from its origin in order to protect a municipal water supply. In the second instance, special precautions are taken to insure dispersal of acid so that the natural alkalinity of the receiving waters can be used to neutralize the acid.

Location and development of several military posts for the Army have likewise required our attention. Plans for the sanitary facilities for these projects have been discussed fully and freely with the engineers employed by the Army. We on our part have tried earnestly to appreciate the need for rapidity of action and decision and the cooperation of the army has been all that we could ask. It would perhaps be inappropriate to discuss in detail the size, location, or type of these projects.

Our experience with naval projects has naturally been much more restricted to date, but we hope very soon to establish the same friendly cooperative relationship that we now enjoy with the Army. We feel that as soon as the responsible people in this branch of the service find out that our interests lie in helping them along, and that we can and will give prompt and sound answers to questions, and that cooperation with us will enhance and not impede their projects, we will have little difficulty.

Another activity of the department materially increased by the war activity is the licensing and supervision of operation of trailer coach parks. Like other activities, this problem was with us before the war, and has simply been intensified since its beginning. In 1941 the State Legislature passed an Act requiring the licensing of trailer coach parks. There were upwards of 125 such parks in Michigan with year-round occupancy, perhaps 80 of which were located in the Detroit metropolitan district. They averaged about 65 trailers per park—the larger ones having about 175.

In the provisions of the Act, various specifications are set up based on an assumed occupancy of three persons for each trailer. Actual count at a considerable number of parks indicates an occupancy of 2.4 per trailer. Water consumption records vary greatly from one park to another but after a year's observation it is believed that an allowance of 110 gallons per trailer or 45 gallons per capita per day is about right, when the park is fully equipped with the fixtures required by the legislative Act.

Need for supervision is indicated by the fact that only eight out of nearly a hundred of those so far inspected were able to secure unqualified licenses. Eighty-eight more were given temporary licenses, good for sixty days, while improvements were being made. In some instances if a good showing has been made, the temporary license has been extended. There are now eight parks under construction which will provide for an additional 450 trailers, six for 1030 trailers with construction pending, and an estimated 1000 trailers to be provided for in several government financed projects.

It is of interest to note that proper disposal of waste matters constitutes the item of greatest delinquency among parks inspected, and presents the greatest mass difficulty.

Costs of these parks vary greatly, as would be expected. It is estimated that at the present time a 50 trailer park, fitted out in accordance with the requirements of the state law, will cost about $12,000 or about $240 per trailer. The average rental received from users in the Detroit area is about $3.00 per week.

With the difficulty that is being experienced in providing housing in our larger industrial centers, and the question as to the advisability of building permanent housing for war workers whose employment may terminate anytime, it seems that the trailer coach will be increasingly used at least for the duration, and control of sanitary conditions in the trailer park becomes a problem of great importance to the war effort.

We have, of course, cooperated fully with the office of Civilian Defense and the A.W.W.A. in developing mutual aid programs among our municipalities and in making inventories of our various water departments. We have made the required investigations of personnel and equipment at the 23 cities of Michigan selected as being of major importance to the war effort and filed them with the appropriate Federal agency. Because of their nature it has obviously been necessary to give the water works systems of the state much greater attention along these lines than has been given sewerage systems or sewage treatment works. However, material prepared for distribution by the O.C.D. has been forwarded to our treatment plant operators.

From reports that have reached us, apparently we have suffered in loss of personnel somewhat less than some of our neighboring states. However, we have found it necessary to replace several plant superintendents, and in some instances there has been a rate of turnover in employees much too high for good operation. We feel it is the duty of each superintendent to consider the qualifications of his employees carefully and plan as far as possible on what is to be done in case any employee, including himself most particularly, leaves the plant for any reason.

Generally speaking, our sewage treatment plants have not suffered by the introduction of new wastes due to the war effort. A few have encountered difficulty from excessive quantities of oil reaching the sewers. Several have had increases in quantity of sewage sufficient to disrupt normal efficient purification. Such new plants or additions to old ones as are currently under construction are of course using as little as possible of vital materials. Designs must be adjusted to meet the availability of materials.

Considerations of priority have made it necessary to defer construction of several plants; in one instance where the case had been bitterly fought through the State Supreme Court, and in another where months of negotiation had resulted in the plant being placed under construction, completion of which must now await more favorable times.

There are dozens of other problems of varying sizes and kinds that have confronted us. Our policy has been to try to work out the best practicable solution consonant with the needs of the case and bearing in mind the necessity for keeping first things first.

We do not propose that any project in Michigan shall be so conducted that one life in the armed forces shall be imperiled to save the lives of all the fish in our streams.

We are not at all disposed to solve our sanitary problems at any cost, without regard to current world affairs. But neither are we disposed to shrug our shoulders and say "It's war—nothing can be done" when the application of a little money, a little labor, some materials, and whatever amount of sound effort and enterprise that may be needed can prevent the development or continuation of undesirable or dangerous conditions.

Discussion

C. W. Klassen

Chief Sanitary Engineer, Illinois State Department of Health, Springfield, Ill.

Mr. Shephard has described problems that are real and alive and not all with the typical story-book ending where everyone lives happily ever after. The Michigan experiences are typical of those in many other states.

One of the greatest sanitary problems of a Department of Health during wartime is that of carrying on a program of clean streams based upon pollution affecting aquatic life, agriculture and public health. The greatest wartime effect has been the necessary limitation placed on the use of critical construction materials and the justified use of these materials only when a public health danger is involved which directly affects the war effort. While it is a commonly accepted fact that sewage treatment is necessary for the protection of health, relatively few treatment works are based upon actual proven public health hazards and extremely few situations can be shown where the public health hazards that may be involved directly affect the war production program.

One of the problems which is becoming more apparent to state health departments is the necessity of carrying on a stream pollution abatement program based upon a temporary lowering of stream standards. For example, in some instances where critical material is involved we must accept the decision of temporarily sacrificing fish life in order not to permanently sacrifice human life. In some cases the best use of critical materials has resolved itself into dispensing with either fish or Japs, with apologies to our finny friends for placing them in the same class with our enemies.

The mechanized nature of World War II requires that industry and natural resources combine to play the deciding role. In industrial states there are many interesting examples of industrial stream pollution problems brought about by the war efforts.

The conversion of distilleries to alcohol production, combined with the increase of production beyond the capacity of equipment for handling the wastes under normal whiskey production, brings about a real pollutional problem. This definite problem is facing many state health departments and alcohol-producing industries where in many instances it has been practically impossible to obtain materials for increasing waste treatment facilities for handling the greatly increased alcohol production. One interesting fact must be noted, that many of these industries are proceeding with applications to the War Production Board for such equipment, with the realization that the recovered wastes are a valuable byproduct. In one instance in Illinois one industry recently obtained authorization for equipment for waste recovery from the War Production Board when it was found that a byproduct valuable in the prosecution of the war was recoverable.

War has brought another boom to another industry—that of cheese making where our American cheese makers are now producing some of the products formerly imported. This has resulted in many cheese plants being scattered throughout dairying states with the results that the wastes when discharged into municipal sewer systems have upset the treatment works in small municipalities.

Similar interesting experiences could be cited of major waste treatment problems caused by the increase in food canneries where large packs are being made for consumption of the armed forces. While an army travels on its stomach, the modern army also travels on petroleum. Thus states where oil is produced and where refineries are located come in for their share of pollutional problems.

With many streams throughout the country taxed to their capacity to absorb increased pollutional loads as a result of the expansion of war industries and increased municipal pollution, one of the real wartime problems confronting state health departments is that of impressing upon sewage treatment works operators the need and importance of operating their existing facilities to obtain the maximum degree of treatment from each of the units.

Sewage Research

A CRITICAL REVIEW OF THE LITERATURE OF 1942 ON SEWAGE AND WASTE TREATMENT AND STREAM POLLUTION

By Willem Rudolfs, *Chairman*, H. E. Babbitt, T. R. Camp, Ed. J. Cleary, G. P. Edwards, E. F. Eldridge, R. Eliassen, H. A. Faber, A. J. Fischer, H. W. Gehm, H. Heukelekian, C. C. Ruchhoft, L. R. Setter, L. W. VanKleeck

Committee on Research, Section A, Federation of Sewage Works Associations

It is natural that the review of the 1942 literature published on sewage and waste treatment not only reflects war activities, but is more or less dominated by construction and operation of treatment plants for the armed forces. Technical literature from foreign countries, with the exception of British, was greatly curtailed. In spite of the war the volume of printed matter pertaining to research, operation and development has not greatly decreased, but the emphasis has been more on improvement of comparatively new developments as well as improvement of established treatment methods.

War production plants discharging large quantities of wastes, mostly concentrated acids, affect many local sewage treatment works. On account of greatly increased production, industrial waste treatment processes are developing, but not at a sufficient rate to cope with the growth of the problem. The majority of the industrial waste treatment processes appear to follow lines previously indicated by domestic sewage treatment methods and are also influenced by borrowing from the metallurgical field.

Because of the scarcity of certain materials, several innovations and aids to practice were inaugurated. Wood and unreinforced concrete were adapted to a variety of new uses, including large wooden settling tanks and digestors, manhole covers, measuring weirs, gates and pipe lines.

The sludge digestion processes appear to be fairly standardized, but there are indications that several new methods, including aerobic digestion and combinations of thermophilic and mesophilic digestion, may come to the fore in the near future. Improvement of established processes continues.

It is no wonder that in these times recovery of by-products, particularly the use of sewage sludge as a subgrade fertilizer and soil improver, is expanding. Sludge treatment and disposal problems remain important at many plants. Although minor improvement in existing methods have occurred, no entirely new or greatly improved method has appeared.

The number of high rate trickling filters installed has increased materially. At the same time we are beginning to obtain considerable information regarding operation, and its limitations begin to become clear.

We have as yet no real information dealing with the biological aspects of high rate filters as compared with standard low rate filters. The fundamental processes involved are still only hazily understood.

In the activated sludge process, greater flexibility seems to be accomplished by step aeration. Attention has been paid to careful control. In respect to control, a number of simple, relatively accurate and rapid analytical methods are needed for the activated sludge and other treatment processes. Perhaps insufficient concerted effort has been made to develop such methods. This applies as well to improvement of existing and development of new analytical methods for control and research.

In addition to a few stream surveys, some additional information regarding the biology of streams has been published.

A summary of all known information on the presence of poliomyelitis virus in sewage and the possibility of infection indicates that, in nature human fecal material is a copious source of the virus, that the virus occurs and is virile in sewage, but it has not been convincingly shown that epidemics may result from polluted water.

Post-war planning is necessary during the war. Practically all of the planning is concerned with post-war construction, some is concerned with more economic service and operation of sewage and waste treatment. Abatement of stream pollution on a wider basis (regional) is foreshadowed. More intensive use of streams for domestic, industrial and recreational purposes is under study. The Research Committee of the Federation is expanding its work in an effort to stimulate research by compiling and publishing the research problems under study in the United States and Canada. The committee is also acting as a clearing house for problems which need study and solution. Of particular interest in respect to post war planning for sewage research is the suggestion made by Mr. W. T. Lockett in his inaugural address as President of the (British) Institute of Sewage Purification. He suggests that a moderate contribution be made by all who benefit by research, without putting a burden on any section of the community at large. In England a contribution of one per cent of the annual national cost of sewerage and sewage purification would produce a national research fund of over $400,000 per annum. This amounts to about one cent per capita a year. How much could be accomplished if such a fund were made available, is difficult to say, but past experience has taught that money spent in research was repaid in the long run many times over in health, welfare and lowered cost.

The annual review presented is not complete, but the available material has been scrutinized, and continued advancement in theory and practice is shown.

Biology and Chemistry

Sewage and Disease.—Recent findings as reported by Paul and Trask (166) tend to place poliomyelitis in the category of intestinal diseases. The virus is quite stable and is more resistant to chemicals than certain bacteria such as *E. coli.*

Examination of a number of sludge samples made by Wright, Cram and Nolan (243) revealed that ova of parasitic helminths were absent in samples obtained from southern states; but over one-third of the samples obtained from army camps showed the presence of these ova. Eggs of *Ascaris lumbricoides* were encountered most frequently. Viable ova were found in all stages of treatment from sewage to the final dried product.

Phages potent against typhoid and dysentery organisms were readily isolated from Calcutta sewage by De and Paul (58). It was found that phages active against typhoid organisms increased during the enteric season.

Bacterial Oxidation Processes.—Moore, Ruchhoft and Wattie (159) studied oxidation reduction changes brought about by coliform organisms in sterile and synthetic sewages. Coli and aerogenes organisms in quiescent cultures were able to effect a lower oxidation reduction potential in the presence of glucose than when sugar was absent. Under aerobic conditions, more positive Eh values were obtained although both organisms brought about reducing conditions in spite of the presence of adequate oxygen supply. Under anaerobic conditions, both Eh and pH values dropped but the utilization of glucose for synthetic purposes continued after a minimum potential was reached. Aerogenes was able to utilize the end products of metabolism with a more positive drift of the potential than coli organisms which were not able to utilize the end products.

Rahn and Richardson (178) reported that in anaerobic cultures the logarithmic phase of growth is of short duration because of the exhaustion of oxygen in the medium. Further multiplication at the same rate proceeds only on the surface but not on the bottom of quiescent cultures. Aeration does not increase the rate of multiplication but maintains it constant for a longer time, thereby yielding a much larger bacterial crop. However, there is a delayed start of multiplication in aerobic cultures because oxygen is harmful to resting cells by reacting with cell constituents. New food does not diffuse as rapidly as oxygen into a cell and as a result, oxygen is utilized to oxidize the cell constituents.

Wattie (236) found that the various zoogleal bacteria isolated from activated sludge and trickling filters belong to one group. The organisms are short Gram-negative rods, do not produce H_2S or acetyl-methyl carbinol, produce acid from arabinose and produce cell capsules.

Preliminary observation of the activated sludge plant at Huddersfield, England made by Reynoldson (184) indicated a close correlation between the oxygen absorption test and B.O.D. of the effluent and the number of Vorticella in the mixed liquor.

Allen (3) reported that aeration increased the numbers of bacteria in sewage. Very few aerobic spore forming bacteria were found. Acid forming bacteria were present but were not predominant.

Heukelekian (105) was not able to show an increase in the B.O.D. reduction of sewage by the addition of yeast.

Experimental evidence obtained from various angles by the same author (106) indicates that the oxidation of carbonaceous materials does not inhibit or retard nitrification as long as conditions remain aerobic and the oxidation of the carbonaceous materials does not create a deficiency of nitrogen and further provided that there is an active nitrifying flora.

McCool (151) conducted laboratory investigations on the decomposition of kitchen wastes. The materials collected varied in composition and availability. The speed of decomposition was accelerated by placing them in an aerated and heated chamber, by the addition of inoculum from active composts and by the addition of steapsin. A rise, followed by a decline in the percentage of nitrogen, took place as decomposition proceeded. The temperature of the bulk samples when limed and inoculated increased more rapidly than in the control. The rate of nitrate formation was slow when these wastes were added to the soil.

Cultures of bacteria capable of attacking crude oil, lubricating oils, vaseline, asphalt and other petroleum fractions were isolated from soil by Stone, Fenske and White (216). It was found that light to medium weight fractions were more susceptible to attack than heavy viscous portions and that the paraffine fractions were more readily broken down than the aromatic types. The breakdown of these compounds is the result of oxidation and is characterized by emulsification and a decrease of pH. The organisms were all motile rods including Pseudomonas.

Zobell and Grant (244) reported that bacteria were capable of oxidizing rubber. Oxygen utilization by a one gram quantity of various kinds of rubber was 5.1 to 6.7 p.p.m. in 5 days. Oxygen was utilized even by sulfur free pure latex.

Kraus (131) reported the presence of relatively high concentrations of compounds with properties similar to riboflavin in activated sludge and humus tank sludge. It was found in smaller quantities in primary sludge which was further reduced by digestion by about 70 per cent.

Laboratory Methods and Analytical Procedures

Investigators and operators who recognize the problems of sampling and analysis in the control of particularly secondary treatment processes will have an appreciation for the pioneering development of automatic recording instrumentation during the last few years. The use of the dropping mercury electrode for the determination of dissolved oxygen in dairy products by Hartman and Garret (104) and the continuous recording of dissolved oxygen at different locations in an activated sludge aeration tank by Ingols (117) are examples of progress during the last year. The former article indicates the accuracy which might be achieved in the analysis of milk (or certain industrial wastes) and the latter on the major fluctuations of dissolved oxygen in an aeration tank during the day, at different locations in the tank, and for different B.O.D. loadings. Somewhat akin to the dissolved oxygen recordings are the oxidation-reduction potentials observed in laboratory activated sludge experiments by Rohlich, Sarles, and Kessler (186).

Manuilova (143) reports a good correlation between the bacterial count of water and the oxidation reduction potential.

In colorimetric analysis Reberg (181) found that selenium photoelements increased the sensitivity of photocolorimetric readings two to 2.5 times. Pomeroy (174) found added color stability and greater color intensity in a modified thiocyanate method for the determination of iron in sewage. Ten ml. of acidified and clarified sample in a 50 ml. Nessler tube is oxidized dropwise with dilute $KMnO_4$ to pink for 1 minute then diluted to 50 ml. with methoxyethane or methyl cellosolve containing 40 g. ammonium thiocyanate per liter. The resulting immediate coloration is compared with standards prepared in the same way. The colors are stable for 15 minutes. Samples containing more than 20 p.p.m. Fe should be diluted initially. A new simple method for the colorimetric estimation of divalent iron based on the reaction of divalent iron with O-nitrosophenol to yield a green inner-complex salt was reported by Cronheim and Wink (54). The method is sensitive to 0.001 p.p.m. Trivalent iron, cobalt and palladium do not interfere. Copper, nickel, and mercury form red or reddish violet compounds. Tariverdyan and Saakyan (220) estimate nitrite nitrogen in water by means of gentian violet. The color of 0.001 per cent solution of gentian violet changes from violet to blue in the presence of nitrite nitrogen in an acetic acid medium. The limit of sensitivity is 0.003 p.p.m.

Ruchhoft and Placak (187) found that the best inhibiting reagent tested for the preliminary clarification of mixed activated sludge liquor in the Winkler determination of dissolved oxygen consisted of a solution containing 50 g. $CuSO_4$, 32 g. sulfamic acid, and 25 ml. glacial acetic acid per liter. Ten ml. of this reagent added to a liter bottle subsequently filled with mixed liquor proved to be about twice as effective an inhibiting agent as $CuSO_4$ alone, produced less interference with the starch-iodide end-point, and destroyed the nitrite nitrogen.

Moore and Ruchhoft (158) call attention to discrepancies which occurred when the B.O.D. of sewage plus river mud supernatant liquor was computed from determined or calculated initial D.O. values. The latter frequently gave much higher results. The data and description of the dilution technique was somewhat limited to permit interpretation but nevertheless it does point to the need of greater standardization of dilution technique and a possible greater recognition of the speed of microbial transformation of sewage organic matter by mass inoculation from partially decayed mud. Lea (135) and Sawyer and Williamson (194) report on the discrepancies appearing in the B.O.D. test of certain industrial wastes if deficient minerals are not supplied in the dilution water.

During recent years many studies have been made to eliminate the discrepancies of the B.O.D. test. To the amateur the method must be most confusing. With due respect to the value of the B.O.D. determination, particularly in stream pollution problems, for practical purposes of plant control a more simplified test might be sufficient. Thus wet combustion methods might be improved and standardized in light of the recent studies such as Gibson's (86) differentiation between animal and vegetable pollution in water.

Sedimentation

Gould (90) describes the final settling tanks at the new Bowery Bay activated sludge plant, in which the returned sludge is taken off at the effluent end of the tanks. The scraper blades are designed to move in the direction of flow of the liquid at velocities up to 3 f.p.m. It is hoped thereby to promote better concentration of the sludge and to subject all of the sludge to a more uniform time of settling. The blades are feathered to minimize eddy currents on their return course through the upper part of the sludge blanket.

An excellent review of operating experiences of primary settling tanks of the "separate" type has been compiled by Wisely (241) from data submitted by the operators of seventeen plants. Among the topics treated are: operation of sludge collection equipment, methods, frequency and times of sludge withdrawal, sludge withdrawal rates, skimming, scum handling and general maintenance. The data are of value to both designers and operators.

Methods of design of grit chambers of the American type are presented by Camp (44), with special emphasis on the significance of velocity control. A new method of design is presented which permits the regulation of the velocity by the operator to any value within the limits permitted by the design.

Chemical Treatment and Flocculation

Research publications predominated in the field of chemical treatment throughout the last year. Construction of plants employing such processes during the previous year was limited to nine small plants as reported by Cohn (50). Also only one paper submitting operation data appeared. This, by Gould (90) presents performance data at the Coney Island plant covering a five year period. Over this time an average of 58 per cent of B.O.D. and 76 per cent suspended solids reduction were obtained when chemicals were employed at an average cost of $2.71 per m.g. While these removals would generally be considered low for chemical treatment, they are actually high when the quantity of chemical employed, as indicated by the low cost figure, is considered. This is indicative of highly efficient operation.

Most of the research has consisted of attempts to step up the efficiency of chemicals by seeking new ones, applying existing ones in such a manner that efficiency is increased or combining them with other methods of treatment to obtain results superior to those obtainable with chemicals alone.

Olin, Box and Whitson (163) present some laboratory experiments in which bentonite was employed as a coagulant. Results showed that 50 p.p.m. of bentonite added to a strong sewage was capable of removing a portion of the solids and hence reduce the B.O.D. Higher dosages did not greatly increase removal. Sludge volumes were practically doubled by the use of this material. In general, the removals observed did not exceed substantially those obtainable by mechanical flocculation and settling without chemical addition. Combinations with a common coagulant or possibly some means of activation might render the use of bentonite for sewage treatment more promising.

That the calcium oxide content of hydrated lime is not the only factor effecting sewage coagulating power is brought out in a paper by Rudolfs

(188). Results of coagulation tests at two plants with commercial hydrated limes of similar CaO content but produced from different limestone deposits are presented. Suspended solids reduction with the various limes alone and the limes in combination with iron salts was measured over periods of about a week. The tabulations of the data collected showed that lime manufactured from the Franklin stone produced good results more consistently when employed both alone and in combination with a coagulant when similar dosages of lime were employed, thus reducing treatment cost. It was concluded that behavior of a lime in respect to coagulation is a better index of its value in sewage treatment then the specifications now prevailing.

While not dealing with sewage treatment, a study of limes by Clark, *et al.* (48) is of interest in that it is a step toward explanation of Rudolfs' observations. The x-ray diffraction patterns and electron photomicrographs of different limes were obtained.

Distinct differences due to particle shape were noted in the x-ray patterns. These suspected differences in particle shape were substantiated by the images observed under the electron microscope. That different shape particles could be produced by varied methods of burning and hydration was demonstrated as well as the fact that particle shape effects some physical characteristics of lime. Structure of lime particles may determine the efficiency of lime for sewage treatment. If this could be controlled in manufacture, a lime might be produced which is far superior to those now marketed for sewage treatment.

Electro-dialysis as an aid to sewage treatment was introduced by Slagle and Roberts (205). In their article an excellent review of past attempts to treat sewage by electrical methods is included. Laboratory experiments demonstrated that sewage could be flocculated by electro dialysis. It was found that anions present in a sewage catolyte passed through a membrane, allowing cations from a sludge anolyte on the other side to diffuse into the sewage and there hydrolyze, resulting in coagulation of the sewage solids. As the sludge remaining after treatment was filterable, possible dual treatment was suggested.

Long period pilot plant results with this process are summarized, demonstrating suspended solids reductions from 75 to 83 per cent, and B.O.D. reductions from 67 to 75 per cent could be consistently obtained with the aid of a low dosage of ferric chloride.

Definite solids loss on dialysis to the extent of about 16 per cent was found to occur. The pH of the sludge dropped to around 3.5 on dialysis and yielded on filtration a cake containing from 55 to 68 per cent moisture. A critical pH of 3.4 was observed below which sludge became less filterable. The changes brought about in the sludge are attributed partially to anodic oxygen and hypochlorites.

Asbestos diaphragms with current densities of about 0.3 ampere per square foot of anode surface with a potential drop of 4 volts between electrodes produced optimum results. Results of a typical test showed that 181 KWH are equivalent to 408 pounds of ferric chloride and 416 pounds of CaO as far as sewage and sludge treatment are concerned.

In calling attention to the lack of interest in mechanical flocculation in England, Hurley (115) points out the possible uses of such treatment. In illustrating this point, results obtained by the process as compared to plain sedimentation are presented. The clarifying effect of waste activated sludge when flocculated with sewage was shown as well.

In a patent assigned to the Emulsions Process Corporation, Ditto and Leftwich (63) describe a process whereby sewage is violently mixed with an oxygen-containing reagent liquid flowing in a pipe under pressure. The mixture is discharged into a volume of sewage which is conducted through a deaeration channel in which clarification takes place.

Trickling Filters

During 1942, high rate filters have been extensively used in U. S. Army Camps and much has been written about them by the personnel of the Repairs and Utilities Branch, Corps of Engineers of the War Department, but as far as the fundamental principles are concerned, no materially new information has become available.

General Operation.—Public Works (12) published a text for operators which provides basic instructional material for new operators. A similar compilation was published by Banta (30). These texts should prove useful to those unfamiliar with elemental sewage plant operation and design. A booklet for engineers has been published by the Pacific Flush Tank Company (165) containing engineering data, design and flow diagrams, charts and tables.

Tatlock (221) lists the basic functions of the filter and sees the major problem as one of finding and maintaining an environment which will favor and stimulate the activities of any desirable forms of biological life.

The Ward Process of Biofiltration (66) is a patented system which includes double recirculation of the filter effluent of the biofilter back to the inlet of the primary settling tank plus the recirculation of secondary settling tank effluent or contents back to the inlet of the biofilter. Primary and secondary clarifiers are of equal design which simplifies construction.

Thompson, from Leeds, England (223) shows that a smooth gravel yields a lower operating efficiency, because there is less area of filter medium in contact with the sewage. If a high quality effluent is desired, broken stone or coke is recommended.

In view of the necessity of conserving critical materials, Gregson (92) used Everite pipe and couplings to replace the broken arms of his sprinkling filter which had originally been iron. Asbestos cement pipe has replaced iron pipe in many U. S. Army Post plants (5).

Trickling filters operation is not limited to a single flow-sheet. The filter at the Liberty, N. Y. (13) plant operates as a biofilter in summer and as a straight trickling filter in winter. The summer load on the filter is given as 2.3 lbs. B.O.D./cu. yd. rock; the winter load as 1.25 lbs. During the summer, with flows of 0.56 to 1.10 m.g.d., the following analytical results were obtained: B.O.D. raw 280–420 p.p.m.; final effluent 6–10 p.p.m.; suspended solids, raw, 172–432 p.p.m., final effluent 2–9 p.p.m.

Montgomery (157) derives many conclusions from operating results from eight aerofilter plants. He bases his conclusion on a minimum flow-rate of 12–13 m.g.a.d. and an average daily recirculation of 30 per cent of the raw sewage flow. The curves are used to predict the quality of any proposed plant effluent on the basis of loadings per cu. yd. of filter media for either single or multiple stage operation. The conclusions are reached under virtually ideal conditions rarely existing. The pilot plants have been operating for only a relatively short period of time.

Gillard (88) makes claims for the virtues of Accelo-filters. He explains the Accelo-filter system as one with a unique, controlled direct circulation (secondary settling tank effluent to filter inlet) providing for inoculation with aerated and activated material and producing accelerated biological oxidation.

The status of biofiltration as of July, 1942, has been reviewed by Fischer (79); 150 biofiltration plants were in operation or under construction, 93 of which were in army or navy camps, airports and ordnance work.

Treatment at Army Cantonments.—The sewage disposal problems at army camps have been presented by several authors. Hansen and Hill (103) present general recommendations.

Based on subsequent actual operating experience of these army cantonment sewage treatment plants, Stanley (215) reports that provisions for unforeseen contingencies in reasonable population increases and uncertainties as to actual sewage quantities will be made in future plant designs.

Kessler and Norgaard (125) (126) state that the responsibility of proper operation of these plants is placed with the Repairs and Utilities Section of the Engineer Corps of the U. S. Army. Grease removal is a major problem, which is attributed to inefficient grease traps in kitchens and laundries. Three posts using single-stage, high capacity filters have had operating difficulties due to deficient primary treatment, while one post filter uses dual recirculation and showed the best results of any single-stage plant. The results of the several posts, using two-stage biofilters, show the adverse effect on operating efficiency caused by infiltration, excessive supernatant withdrawal to the primary clarifier and high recirculation ratios. All types of high capacity filters have shown filter fly breeding but to a lesser extent then low-rate filter. Flooding and chlorination are used as control measures.

To save critical material, it is possible that the army can eliminate two-stage plants and have the single-stage designed for dual recirculation. The disadvantages of a high capacity filter are extensive fly breeding and a discolored effluent having a brownish-red tinge. The authors believe that the two functions of a high capacity filter are: (1) oxidation, and (2) work likened to a conditioner or colloider similar to the performance of an activated sludge unit.

The five army biofilter plants (11) are loaded up to or beyond design capacity. The recirculation ratios vary from 1 : 1 for a two-stage plant to 2 : 1 for a single stage plant.

A description of the operation of an army camp high rate trickling filter sewage treatment plant (12) designed to accommodate a population varying from 3,500 to 35,000 relates that all the units are so interconnected as to permit the plant to produce a varying degree of treatment or to produce a fixed degree of treatment regardless of flow variations.

The unique feature of the sewage treatment plant at Camp Edwards (10) is the ultimate disposal of the final effluent into the ground, there being no body of water to receive it. The biofilters discharge their effluent, through a clarifier onto 12 acres of intermittent sand filters at a designed rate of 250,000 gals. per acre per day. The effluent of the sand filters is absorbed by the sandy subsoil.

The sewage plant serving new War Department Office Building (9) in Arlington, Va., was unprecedented in design. As the building will be occupied only 9 hours a day, 6 days a week, the sewage plant design was based on this unique flow characteristic. The two high-rate filters will be dosed at a rate of 10 to 25 m.g.d., are 85 ft. in diameter, 6 ft. deep and have forced ventilation.

Research.—Biology of the sprinkling filter is discussed by Holtje (110) with accompanying photographs of some of the common types of micro-organisms.

Hanna, Phimister and Eliassen (102) present work on experimental biofiltration, treating weak domestic sewage and using various flow sheets. Six runs were made, varying dosing rates and with single and two-stage treatment, using rates of application varying from 32.6 m.g.a.d. to 99 m.g.a.d. The results obtained with the maximum rate indicated that the dosing rates are of secondary importance as long as the limiting B.O.D. loading factor in lbs. per cu. yd. of filter media per day is not exceeded. With single-stage, complete treatment and dual recirculation, the investigators concluded that this type of treatment was preferable, for economic reasons, to two-stage treatment where a higher degree of purification is required. The authors advance the following preliminary conclusions of this initial stage of their work: B.O.D. removal is directly proportional to the filter load applied regardless of the stage of treatment, recirculation ratio, or actual filter dosing rate up to the maximum load applied of 5.48 lbs. B.O.D. per cu. yd. of filter media per day. The per cent removal in the unit remained constant for all runs. A residual B.O.D. of 10–20 p.p.m. remains in the final effluent regardless of the type of treatment. The average per cent over-all removal varied slightly for each run, because of the weak raw sewage and the relatively constant residuals of the final effluents.

Dekema and Murray (60) (61) report the results of their investigations on the operation of artificially ventilated filter beds versus ordinary open filter beds. Settled sewage was applied to two filters, one open and one enclosed, but provided with down-draft ventilation introduced by a centrifugal fan. The results indicate that the enclosed filter was able to treat to substantially the same degree of purity slightly more than 2.15 times as much of the same sewage per cu. yd. of media as the open filter. According to the authors, there does not appear to be any determinable relationship between the quantity of air fed to the filter and its performance. The enclosed filter was found to be more stable toward volume and strength shocks than the open filter. The enclosed filter was not free from flies nor was there any objectionable odor.

Continued work on two artificially ventilated filters allowed the following conclusions to be drawn: (1) increased flexibility of operation with less likelihood of ponding, (2) controlled reversals and adjusting load by mixing influent with recirculated effluent were most satisfactory, (3) large intermediate and final settling tanks can be detrimental instead of beneficial, and (4) heating the air is unnecessary and downward air flow more satisfactory than an upward flow. On the basis that the purification capacity of an open filter gives a performance of one, the authors calculate the performance ratio for the various arrangements studied as follows: 2.3 for enclosed ventilated filters (12 ft. deep) and 3.2 for enclosed ventilated filters operated in series.

Watson (235) states that the chief difficulty with biological filtration is caused mainly by poor aeration on account of blockage of the voids by excess bacterial sludge and that any method which lessens this blockage is bound to increase the purifying capacity of the filter. Recirculation increased the purification and convinced the author that the value of recirculation rested in the maintenance of dissolved oxygen in the filter feed. When the strength of sewage increases, the recirculation ratio has to be increased in order to maintain dissolved oxygen in the filter feed. The presence of dissolved oxygen in the filter feed, according to the author, causes the sludge found in ordinary filtration to dislodge and to build up an entirely different type of life. Large quantities of slime do not form in the filter in the presence of dissolved oxygen irrespective of the influence of flushing velocities.

Experiments with high rate filtration were continued at the Lawrence Experiment Station (148). The sewage flow is at the rate of 20 m.g.a.d. and the total flow at the rate of 80 m.g.a.d. During 1941, the recirculated effluent showed 70 per cent removal of B.O.D. as compared with 53 per cent when recirculation was not used. The reduction in suspended solids after one-hour settling were 71 and 65 per cent respectively. When the recirculated effluent is applied to another filter at the rate of 11 m.g.a.d., the effluent approaches in quality that obtained from a low rate trickling filter. The average rate of the two filters is almost 7 m.g.a.d. and the B.O.D. load 4,100 lbs. per acre foot daily. Experiments were also run on sand filtration of effluent from high rate filters. The rate of application on the sand filter was 250,000 gallons per acre daily. The effluents from the sand filters were stable and gave B.O.D. and suspended solids reductions of about 90 per cent.

Activated Sludge

The most important publication of the year in the field of activated sludge is the report "The Operation and Control of Activated Sludge Sewage Treatment Works" by a committee of the Public Health Engineering Section of the American Public Health Association under the chairmanship of Langdon Pearse (168). Its availability and character make unnecessary any attempt to abstract it.

After two years' experience, Gould (90) finds the advantages of step aeration to be greater flexibility, a longer contact period for the sludge, the storage of more sludge in the tank for the same effluent concentration and therefore increased time available for conditioning, decrease in the biological shock on initial contact with sewage, and more uniform food distribution to the sludge. At Tallmans Island, it has been found best to use both conventional and step aeration as conditions dictate. Step aeration seems to be indicated when the volatile content of the sludge persistently increases, when the sludge index or dissolved oxygen decreases steadily and in the case of abundant sphaerotilus growths. Conventional aeration is used when the primary effluent solids or flow are low or when over-aeration occurs.

McKee and Fair (153) have submitted laboratory data in support of step aeration or multiple point dosing. They find that this system maintains oxygen demands at a more uniform level than the more conventional method of operation, that it renders operation of aeration units flexible and that it is readily incorporated in conventional tanks by the provision of sewage inlets and transverse baffles. They believe pre-aeration of sewage and reaeration of return sludge may be important in equalizing the oxygen demands of activated sludge units.

Two-stage aeration in which the aeration tanks are in series or two stages separated by an intermediate settling tank is said by Scott (200) to be more efficient and less subject to upsets than the standard process. In this two-stage system, the primary aeration stage is one-half the total aeration capacity and sludge from the intermediate settling tank is continuously returned to the primary aeration tank. The second stage aeration and final settling tank are operated much the same as any conventional plant.

Phelps and Bevan (170) in laboratory studies of the Biochemical Process which involves the addition of coagulant (ferric sulfate) to the primary tank effluent and operation thereafter in the manner of the activated sludge process, have shown that the presence of iron in the quantities employed (5–10 p.p.m.) stimulated the growth of the common sewage organism, Aer. aerogenes and after conditioning, increased the rate at which it oxidized organic matter. A pure culture of aerogenes, fed intermittently with synthetic sewage and treated with ferric sulfate, developed an active sludge more capable of performing the two chief functions of activated sludge, namely, rapid adsorption of soluble organic matter followed by oxidation of soluble and insoluble solids, at a much higher rate than that associated with that organism in the B.O.D. reaction. In the presence of a mixture of activated sludge in pure culture and iron floc, not activated, adsorption goes largely to the iron floc to the extent that activated sludge is prevented from performing its ordinary oxidizing function. Given a continuous supply of normal sewage bacteria, the conditioning of the biochemical sludge is rapid. Two or three days is adequate to bring it to equilibrium with a sewage of 200 p.p.m. B.O.D. (soluble) and to build an aeration tank liquor of 1000 p.p.m. suspended solids. They find that this biochemical sludge becomes established in preference to the activated sludge and tends to restrain the development of the activated sludge. The ability of the biochemical sludge to adsorb more rapidly and the coagulating action of the freshly applied chemical seems to give it an advantage over the slower active sludge. This should result in shorter aeration periods and consequent economy in tank volume and in air.

Smith (206) controls the wasting of excess activated sludge by means of a 4-in. valve in the return sludge pump header which continuously discharges waste sludge to the primary settling tank. The amount of excess sludge is affected immediately by a back pressure plug in the return sludge discharge line leading to the mixed liquor channel. This method of control nearly eliminates the operation of excess sludge pumps, thereby reducing power costs and simplifying operation. The continuous addition of a small quantity of excess activated sludge seems to have a beneficial effect on the primary tank efficiency.

Experimental studies on the addition of fine soil to the aeration tanks of the Delta (Johannesburg) Activated Sludge Plant to increase the density of the sludge were so successful that according to Hamlin (99) a permanent unit will be constructed for the addition of soil to the settled mixed sludge prior to its being pumped up to the reaeration tank.

After a careful study of plate cleaning methods, Schade and Wirts (195) concluded that soaking plates for one to two hours in sulfuric acid containing two per cent sodium dichromate, followed by draining and thorough washing consisting of at least ten rinsings in water is most satisfactory. About 75 to 85 per cent recovery of permeability was attained. They believe that aluminum oxide diffuser plates can be removed from Burger type holders and cleaned economically on a full plant scale basis. The cost of plate cleaning including the labor for removal and resetting was just under 25 cents per plate with no appreciable loss in plate breakage or torn rubber gaskets. They found it sound economy to clean diffusers when the blower discharge pressure increase equals 0.5 lb. per sq. in. and the plate permeability drops to 12.

During the dry summer months, primary treatment is not sufficient to permit the discharge of a satisfactory effluent from the bio-aeration tanks at Chesterfield, England. After much experimentation, Hirst (108) found that aeration of the primary tank effluent for one hour with ten per cent return sludge gave the desired result.

Several suggestions were made as to other means for solving the Chesterfield difficulty. Moore (17) believed that a return of heavier activated sludge would enable the plant to function properly. Oliver (17) had solved a similar problem at Rotherham by feeding a mixture of final effluent and filter effluent to the bio-aeration units. Watson (17) stated that bulking caused by lack of aeration might be overcome by diluting the sewage with effluent if a long series of tanks were used, by using a smaller number of tanks in series or by adding only a portion of the return sludge at the beginning of the aeration period and adding the remainder about half-way down the plant after the oxygen demand had been reduced.

Lehmann (136) discussed the operating problems of the activated sludge plant at Hackensack, N. J. The sludge blankets in the final settling tanks are kept only a few inches deep. The dissolved oxygen content of the mixed liquor at the end of the aeration tank is maintained at about 1.0 p.p.m. Bulking occurred on two occasions with dissolved oxygen content of over 2.0 p.p.m. Chlorine addition to the return sludge decreased the sludge index. Some of the other factors considered are (a) the effect of digester supernatant liquor and (b) the removal of settled activated sludge rapidly from the final settling tanks.

Chlorination

Chlorine Availability.—Adequate supplies of chlorine appear to have been available to meet sewage treatment requirements, despite the fact that this material is subject to direct allocation. All orders following the procedure specified (19) under General Preference Order No. M-19 are assigned the highest civilian priority rating of A-2, given only to chlorine used for treatment of sewage and potable water. On the basis of survey data representing about 25 per cent of the U. S. population served by sewage treatment facilities, Schroepfer (199) indicates the chlorine required for this purpose during 1942 to be approximately 13,900 tons.

Chlorine for Disinfection.—Reporting on the third year of operation of the Buffalo treatment plant, Velzy, Johnson, and Symons (231) note that during the latter half of 1941 the chlorine demand of the raw sewage was 28 per cent higher than in 1939–1940. An average dosage increase of only 18.4 per cent was required, however, because improved plant operation resulted through extensive laboratory study of dosage control. The increased demand is attributed to industrial activity.

In a new report, necessitated by the recent population increase, the Hampton Roads Sanitation Commission (100) recommends collection of sewage from the district and treatment at five plants. Design capacity will include facilities for application of 70 lb. per m.g. of chlorine (8.4 p.p.m.) to an estimated 54.8 m.g.d.

Chlorination of the effluent from the present Toronto, Canada, sewage treatment plant has been investigated by Howard (112) as a temporary means of alleviating pollution of Lake Ontario. Application of chlorine in laboratory studies, to satisfy the average 15 p.p.m. demand, accomplished excellent 10 and 30 minute reductions of bacterial counts. However, large increases in counts took place after these treated samples stood for 24 hours. As similar multiplication might occur following the discharge of chlorinated effluent into the lake, this treatment is not considered favorably. Apparently these studies did not simulate actual conditions, since the chlorinated samples were not subsequently diluted with lake water.

Chlorination practice is included in limited operating data (14) on four sewage treatment plants (all of the fine screen type) serving nine sewerage systems in Westchester County, N. Y. During an average month 72.7 lb. of chlorine per m.g. (8.7 p.p.m.) was required to maintain the desired residual of 0.5 to 1.0 p.p.m.

Chlorination for Odor Control.—Studies by Heukelekian (107) show the chlorine dose applied is definitely related to the demand of the sewage and the degree of hydrogen sulfide production. A minimum of 20 to 25 per cent of the chlorine demand should be satisfied in order to keep the sulfide content below 1 p.p.m. for a period of four days, and large percentages of demand satisfaction are required to accomplish longer periods of retardation. Hommon (111) reviews the destructive effects of hydrogen sulfide and illustrates the practical advantage of upsewer chlorination for its prevention as compared with pre-chlorination at the plant for its control.

The successful use of chlorine and ferrous chloride (Scott-Darcey process) for control of odors under a wide variety of conditions was described (21) at an operators' symposium. Pinckney (172) reports the effective application of ferrous chloride to react with hydrogen sulfide and control odors arising from trickling filters. He found recirculation of settled filter effluent to the raw sewage materially reduced the chlorine requirement.

Chlorination for Grease Removal.—Gehm (83) reports on plant scale comparisons of grease removal from sewage by aeration and by aero-chlorination at the South River, N. J., Treatment Works. Sewage was treated with 0.02 cu. ft. of air per gal. and 8.0 p.p.m. chlorine, introduced into the diffused air line. Removals per m.g. averaged 39 lb. of grease by plain aeration and 55 lb. by aero-chlorination, representing an increase of 41 per cent. Only grease removed as scum was measured and, while the actual amount was not significantly increased by aero-chlorination, visual observation indicated the effect to be beneficial. The clarifiers required skimming once instead of three times daily and a general improvement in their appearance was noted.

On the basis of experimental data Weston (238) concludes the additional amount of fats removed by aeration does not warrant the provision of plain aeration ahead of sedimentation for grease removal. In several studies involving aero-chlorination and subsequent sedimentation, the best results were obtained by adding 46.5 p.p.m. of chlorine to a sewage having a fat content of 30 p.p.m. Using an aeration time of seven minutes and a sedimentation time of seven minutes, a fat removal of 86.7 per cent was accomplished.

Gilman and Hartman (89) describe the design and operation of equipment installed at the Tobin Packing Company, Fort Dodge, Iowa, for recovery of grease from pork wastes. Limited plant scale studies showed recovery of chloroform soluble material to average 56.5 per cent of that originally present. When gaseous chlorine (5.0 to 7.0 p.p.m.) was applied with the diffused air, an average recovery of 74.6 per cent was obtained. Since this low dosage apparently increased the actual pounds recovered by 30 per cent, it is considered a worth while addition to the process.

Chlorine in Activated Sludge Treatment.—A committee of the American Public Health Association, in an extensive review (168) of activated sludge plant operation and control, describes experiences—both favorable and unfavorable—with the use of return sludge chlorination to control bulking. Definite advantages are shown to result from this application at Houston, Texas; Lancaster, Pa.; Wards Island Plant, New York City; and

Baltimore, Md. Experience with such treatment has shown no benefit in studies made at Marlboro Hospital, N. J., or at Indianapolis, Ind.

This use of chlorine has been reported by Turner (224) to be successful at the Mansfield, Ohio, activated sludge plant. *Sphaerotilus* is present in the raw sewage but sludge index is low following heavy rainfall, subsequently rising rapidly. When chlorine application was started, a marked improvement in settling characteristics followed within five days. Chlorine doses adequate for control or removal of *Sphaerotilus* produce a turbid effluent but this is not shown by B.O.D. determinations to be detrimental. Until a better method of bulking control is found, chlorine application is considered important for proper sewage treatment. Among other methods described in a round table discussion of activated sludge bulking, Smith (207) mentions chlorination of return sludge as the most important corrective measure at the Lima, Ohio, plant.

Jackson (118) has published details of the method employed at the Jackson, Mich., activated sludge plant to reduce clogging of diffuser plates. Chlorine is added directly from a cylinder connected to the air header supplying an individual aeration tank. Intermittent application of chlorine, never at a rate higher than 15 lb. per day, has resulted in an increased blower discharge (4 million cu. ft. per day increased to 5.5 million cu. ft.). The maximum benefit has been found to result from applying chlorine at a rate of about 4 lb. per hour for two or three hours. After about two years use, this application no longer increases air delivery. All plates have now been cleaned by acid treatment and chlorine will be used as long as it increases air flow. No ill effects of chlorine on piping have been noticed.

Special Applications of Chlorination.—New studies by Kempf, Wilson, Pierce, and Soule (124) to determine the concentration of chlorine required to inactivate two strains of poliomyelitis virus have been reported. They note that, after a contact time of 25 minutes, 1.5 p.p.m. residual chlorine inactivated the MV strain and that 1.0 p.p.m. was the maximum residual which failed to inactivate. In a second experiment, using the DG strain, 1.0 p.p.m. residual chlorine inactivated while 0.9 p.p.m. failed to inactivate. These investigators report, but do not call attention to, the effect of pH on the action of chlorine: At pH 7.0, the residual required for inactivation of the MV strain was only 0.55 p.p.m., but at pH 8.2 the dose required was 1.5 p.p.m. For the DG strain a residual of 0.5 p.p.m. inactivated at pH 7.1 but at pH 8.0 a residual of 1.9 p.p.m. was required. Paul and Trask (166) cite circumstantial evidence that places poliomyelitis among intestinal diseases. They state that their incompleted experiments concerning the resistance of this virus to chlorination have given irregular results.

The liberal use of final chlorination at army camps is cited by Hansen and Hill (103) as being somewhat costly in operation but as economical, since it permits satisfactory operation with provision of less biological treatment than might be required for permanent installations in municipalities. Chlorine may be used to retard decomposition, to reduce B.O.D., and for effluent disinfection.

Eldridge (72) recommends chemical treatment as more suitable than biological processes for treatment of slaughter house wastes in small plants employing intermittent treatment. Chlorine gas is applied until an excess of about 50 p.p.m. over the demand of the waste is reached. The liquor becomes a light tan color and blood proteins, precipitated by the chlorine, are allowed to settle. This does not constitute complete treatment, the B.O.D. removal generally averaging 50 to 75 per cent. The addition of ferric chloride, subsequent to chlorination, enables thickening and dewatering of the sludge.

Control of Chlorination.—Chamberlin (46) discusses the important reactions which occur between ortho-tolidin and chlorine, pointing out that only the reaction involving formation of holoquinones is suitable for colorimetric determination of residuals. Research has established that the mixture of ortho-tolidin and chlorinated water must be at a final pH of 1.8 or lower and that an excess of the reagent must be present at all times. In a committee report, Calvert (43) describes certain proposed changes in the present standard methods of residual chlorine determination and of chlorine dosage control.

Marks and Glass (144) give details of a method for titrating chlorine amperometrically with sodium arsenite in neutral solution using a polarized gold electrode and a silver reference electrode. This method makes it possible to distinguish between free and combined chlorine. Davis (57) has constructed a nomograph which readily provides data on chlorine solubility at temperatures from 10° to 25° C. and at pressures from 0.06 to 1.0 atmosphere.

In plant design, Coburn (49) advises that chlorine control and storage rooms should be separate from other rooms if located in the same building and that access to them should be from the outside only. Where piping to or from chlorine rooms passes through walls and floors, the annular space around the pipes should be plugged tight to prevent chlorine from possible leaks escaping through such openings.

Sludge Digestion

Berry (33) discusses trends in sludge digestion in Canada while an A.S.C.E. Committee Report (169) briefly touches on advances in sludge digestion in the United States.

Research.—Mixed humus and activated sludges in the ratio of 3 to 1 on the basis of dry solids were digested under laboratory conditions within the mesophilic and thermophilic ranges by Lumb (140). The results can best be summarized by the following figures:

	15° C.	20° C.	30° C.	55° C.
Volume of separated liquor per cent of sludge volume	17.6	28.0	10.0	30.5
Per cent reduction of organic matter	26.0	25.3	24.5	25.9
Gas evolved ml./gm. dry organic matter added	164	211	191	166
Suspended solids in supernatant liquor p.p.m.	476	2530	2560	3000
Total tank capacity required on raw sludge volume added (days)	116	56	21	13

Of significance is the greater separation of liquor and the greater suspended solids content of the liquor under thermophilic conditions, and the generally low gas yields from this type of sludge. The digestion of this type of sludge seems to be more sensitive to heat than primary sludge.

Heukelekian (105) describes laboratory experiments in which the effect of baker's yeast on the digestion of seeded primary sludge was noted. Conclusions drawn were that the yeast did not hasten the stabilization or digestion of the raw sludge. Rudolfs and Stahl (191) present data to show that no phosphine is formed when sludge containing phosphorus compounds is decomposed anaerobically.

Control.—Symons and Kin (218) (219) give a rapid method of determining the solids content of raw or digested sludge. The method which is given in some detail should be of value in making digester "inventories." Burley (41) presents a chart that is useful in calculating the volatile matter reduction in a digester from the volatile matter content of the raw and digested sludges.

Design.—Stanley (215) outlines the basis of design setup for digestion tanks in U. S. Army camps. Lingo (137) describes the digesters at a typical army camp, while Velzy (229) gives a brief description of the units installed to handle the sludge at the new War Department Office Building sewage plant. Chase and Flood (47) give design and operating data on the digesters at Greenfield, Mass. Phelps and Stockman (171) briefly describe the digesters at San Diego. Taylor (222) gives details of a unique design of digester in which supernatant liquor is stored in the upper compartment of a two-story tank. A new two-story digester in one tank is described in *This Journal* (67) with the upper compartment for primary digestion and the lower for second stage. Removable mixers and vertical heat exchangers are provided. A vortex circulator in a new digester mechanism is also developed (116) to prevent scum accumulation and to impart a radial movement to the tank contents in the lower portion for the formation of dense sludge. Stafford (214) describes the iron sponge purifier for removing hydrogen sulfide from digester gas.

Operation.—Gerdel (85) in the year's outstanding article on sludge digestion gives detailed operating data of the Cleveland Westerly plant. Operation and maintenance difficulties, chief of which was scum formation and accumulation, are described. Kunsch (132) details unusual operation difficulties at Danbury, Conn., caused by hat fur in the digesters. Scum troubles were extreme and interfered with normal operation of the mixing devices installed in the tank. Of interest is the wide variation in temperature at the top and bottom of the tank. This resulted in high solids in the supernatant liquor. Mathews (149), Howson and Mathews (114) and Cottingham (52) present data regarding the two-stage digester operation at Gary, Ind. The supernatant liquor overflow from the secondary tanks is unusually low in solids considering that mixed raw and activated sludge is digested. This indicates the wisdom of providing ample capacity (6 cu. ft./cap.) where activated sludge is handled. Lehmann (136) describes the operation at Hackensack, N. J. Operation of the digester mixers at this plant were found to be beneficial. Gould (90) describes experiences at the Coney Island and Tallmans Island (New York City) plants. Loadings at the former plant as high as 5.0 lbs./cu. ft./month were reached without adversely affecting results. At Tallmans Island an unusually thick digested sludge is obtained even though mixed raw and activated sludge is digested. This may be accounted for by the very low volatile matter content (58.5 per cent) in the raw sludge.

Erickson (77) describes the operation at Bakersfield, California. Mesner and Nussbaumer (155) outline the starting difficulties encountered at Cheektowaga, N. Y. In *The Surveyor* (18) difficulties with overflow liquor high in solids and the advantage of two-stage digestion in clearing up this overflow liquor at Chigwell, England, are described. Kessler and Norgaard (125) point out in connection with a survey of army camp plants that the supernatant liquor problem is still unsolved. In a later article the same authors (126) state that temperatures are difficult to maintain in digesters built of steel. It is stated that a vacuum type aerator has been successfully operated for reducing the solids content of digester supernatant liquor. It is to be regretted that no details were given on this novel device.

Rawn (180) and Bacon (28) discuss the use of live steam for direct heating of raw sludge at the Los Angeles County plant. Many advantages as compared with the use of heating coils are given. Odors were said to be practically non-existent. No mention is made of the increased amount of digester overflow liquor due to condensation of the steam. Gwin (95) describes sludge heating experiences at Folsom State Prison, California. Pre-heating of sludge by means of steam coils gave rise to odor nuisances.

Gunson (93) in order to overcome the delay of gas production in two-stage digestion, after the addition of raw sludge, mixed the raw sludge with the tank contents twice daily. This kept the gas production constant and increased the yield by about 16 per cent. The reduction of volatile matter in the primary digesters was 56 per cent and in the secondary 30.4 per cent with an over-all reduction of 69.6 per cent. The difference of temperatures in the primary and secondary tank resulted in a supernatant liquor overflow with 2 per cent solids due to thermal action. This condition was improved by bringing the secondary tank to the same temperature as the primary.

Sperry (213) gives complete details of the gas engine performance at Aurora, Ill. Martin (146) describes the gas utilization system at Green Bay, Wisc. Details of the arrangement of gas engines, heat exchangers, gas fired boilers, etc., are given, whereby maximum utilization of gas for heating and power purposes are obtained.

Corrosion troubles with a digester mechanism and heating coils are discussed by Reed (183). The corrosive action was more pronounced near the top of the tank. For this reason it was thought that the presence of the gases in the liquid have some effect.

Data.—Digester operating data at Springfield, Ill., are given by Larson (134), at Urbana-Champaign, Ill., by Wisely and Sidwell (240), at Buffalo,

N. Y., by Velzy and Symons (230) and Velzy, Johnson and Symons (232), at Marion, Ind., by Backmeyer (27), at Massillon, Ohio, by Snyder (212), at Fort Dodge, Ia., by Lovell (139), and at New Haven, Conn., in *Sewage Works Engineering* (16).

Patents.—Howe and Izett (113) show a slot closer for a longitudinal Imhoff tank, whereby raw sludge may be delivered to only one side of the digestion compartments so that the other side may be rested. The closure plate also prevents gas from rising up from the closed off portion through the flow compartment. Downes (68) shows a two-story digester wherein primary digestion is carried out in the upper compartment and secondary digestion in the lower compartment. Behringer (32) describes a process for digesting sludge high in calcium hydroxide, wherein the sludge is treated with carbon dioxide prior to digestion.

Sludge Disposal

Sludge as Soil Conditioner.—The year showed continued and widening use of sludge as a soil conditioner. As the war progresses and animal manures become increasingly scarce, such interest in sludge should naturally result.

Willard (239) of the Spartanburg, S. C., metropolitan district reports that digested sludge produced at two plants in his district is sold to a local fertilizer concern. It serves as a substitute for tankage and is sold on both its nitrogen content and a base price for its humus value. The sludge with about 50 per cent moisture is removed from the drying beds by the fertilizer company, stored on a concrete drying slab where the sludge moisture may drop as low as 7 per cent and then taken to their mill for grinding. The city receives $1.00 per ton base price and $1.00 per unit of nitrogen. As the nitrogen is around 2 per cent, this nets the district about $3.00 per ton. Formerly the district removed the sludge and delivered it to the fertilizer company at a cost of about $2.00 per ton. Since the district has built a drying yard, the fertilizer company relieves the district of this expense. Presumably the drying yard is uncovered. Willard believes Spartanburg may be the first to use this method of disposal in this country.

In Oshkosh, Wisconsin, the demand for digested sludge is so high that the product is now short on the local market. Frazier (80) sells the ground product at $3.50 per cu. yd. or $1.75 per yard for bed sludge. Winter freezing and thawing on the beds breaks up the sludge fibers so that grinding in the spring is not necessary. Sales returns have paid for the plant grinder, paid the wages of an extra man to care for the plant grounds and sell the sludge, purchase trees and shrubs for landscaping, etc. Plot demonstrations of vegetables, flowers and lawn treated with sludge, convince visitors. Oshkonite does not burn, grass will grow in it without soil, and it gives plant growth that cannot be explained on the basis of analysis alone. This is true of all normal digested sludges. The author's conclusion sounds the following key note: "It is contended by the writer that more stress should be placed on the use of sludge as a soil improver, contributing more vigorous and vitalized growth and a greater yield at this time when conservation and maximum production is the key note which is to win this economic war. Sewage sludge can be used . . . on the many 'war gardens.' . . . Sewage works operators can do their bit by popularizing the use of prepared or conditioned sludge in their localities now as never before . . . in advancing an emergency measure, a sound economic practice can be established for the future as well as the present."

At Appleton, Wis. (29), Baitz grinds digested sludge cake and fortifies it to 5.17 per cent nitrogen, 2.07 per cent phosphoric acid, and 2.10 per cent potash by addition of chemicals. The entire sludge output is sold either as unfortified soil conditioner or as "Appcolizer." Again experimental plots were tried, local newspaper cooperation sought, and a little effort put into the work, until the plant product is by far the best soil builder that has been tried around Appleton.

Crowther and Bunting (55) give results on fertilizing experiments with potatoes. Without potash, farm yard manure increased the yield per acre, but sewage sludge had an insignificant effect. On the other hand when potash was used with both farm yard manure and sewage sludges, the yield was almost as good with sludge as with twice its weight of manure. It is pointed out by the author that farm yard manures are more balanced chemically than sludges, a fact well appreciated.

During the year Johnson (120) reported that the larger portion of the output of dried activated sludge from the Chicago Calumet plant is now sold as a fertilizer material.

Schriner (196) at Kankakee, Ill., plans to promote the use of liquid sludge for fertilizing lawns, following in general the scheme reported by Damoose of Battle Creek last year. Schriner has purchased and refitted a used 1,000 gallon gasoline tank for about $23.00, fills the tank by gravity from a sludge bed piping connection, and dumps approximately 24,000 gallons of sludge daily on either vacant land or uses it as a soil conditioner. The saving in sludge disposal cost by this method over drying on sludge beds is reported as less than half, in addition to providing a year-round disposal method.

Rudolfs and Gehm (189) have shown that the average total P_2O_5 content of sludge varies with the type of sewage treatment from 1.5 to 4.6 per cent. Digested sludge contains more phosphoric acid than plain settled sludge. Activated and humus tank sludge have greater percentages of P_2O_5 then settled sludge and digested chemical sludge has the highest P_2O_5 content.

Elutriation of Sludge.—Experience with elutriation of digested sludge at Hartford, Conn., was described by Craemer (53). Two years of operation have shown the following advantages: (1) Lower consumption of ferric chloride averaging 2.51 per cent (dry basis). The yearly saving at present is stated at $1,048. At design flow of 40 m.g.d., an annual saving of $2,800 is expected. (2) The period of sludge digestion can be shortened resulting in a digestion space saving and reduced capital investment. At Hartford this saving was $59,800 which is $4,800 more than the cost of the elutriation tanks and equipment. (3) Less filter room odor. (4) Mess and cost of lime conditioning eliminated. (5) Filter cloth life has been very satisfactory and the blinding of the filter wire mesh has been avoided since lime is not needed for conditioning.

There has been some trouble with the sludge measuring valves on the elutriation hookup. They have a tendency to stick and register inaccurate readings due to gas in the sludge and the grit present. The remedy is a periodic check-up, flushing, etc. A more adequate wash water system resulted when the well points in use were pulled, lengthened and redriven. Grit deposited on the floor of the mixing tanks froze the lower bearing of the agitator shaft. Piping grease to the bearing corrected this. A cross-collector type of sludge sedimentation tank, not used at Hartford, would give a more uniform sludge and require less adjustment of the ferric chloride feed. Arching of sludge also occurs with the three individual sludge hoppers used at Hartford. Squeegeeing the hoppers breaks up the sludge. A single hopper would correct this also. Freezing of the elutriation tanks overnight during severe low temperatures requires that ice be broken up in morning to prevent flight damage. Covering or enclosing tanks would help solve this problem, it is pointed out.

Craemer draws the following conclusions: (1) Sufficient wash water for sludge is necessary. (2) A uniform washed sludge of about 92 to 94 per cent moisture gives excellent filter results. (3) Time of digestion affects filter output although only 15 days digestion produces sludge that can be filtered with but slight increase in ferric chloride dose.

Incineration of Sludge.—Langdon Pearse's Committee (169) reports that figures available in 1941 indicate ten installations using flash-drying and twenty-seven using the multiple-hearth system. However, the flash-drying system is apparently handling more than twice as much filter cake as the multiple-hearth system, and about 20 per cent more dry solids. In the heat drying of sludge for fertilizer, the flash system leads with an output of more than 58,000 tons per year, as against 25 tons for the multiple-hearth system.

Vacuum Filtration of Sludge.—Following recent developments in the metallurgical field, diagonal drainage grids of wood are being tried as a substitute for copper drainage supporting screens on cylindrical vacuum filters at the Calumet and Southwest Works in Chicago (169). Not only the copper formerly used is a war metal, but clogging trouble has been pronounced at some plants with these screens.

Inhibited muriatic acid is added to water in the filter pans at Minneapolis-Saint Paul (156) with the filter drum and agitator in operation for removal of carbonate scale from the pipe lines, filter cloths and vacuum filter parts. After 2 to 3 hours the acid is pretty well spent and solution is drained out and filter washed with water sprays. Acid bath is given after about 350 hours of cloth life with cloth and screen left in place. The treatment increases the economical life of the filter cloth to 500 or 600 hours and also removes the scale from the screen and splines. To clean the pipe lines of scale, the inhibited acid is recirculated through them.

Hageman (97) in a descriptive article on Chicago's Southwest plant listed twelve general operating instructions for vacuum filter crews. Most pertinent were: (1) Keep overflow of conditioned sludge to minimum.

(2) A filter vacuum of 24 to 25 inches means proper conditioning of sludge; 20 to 22 inches over-conditioned sludge; 26 to 28 inches under-conditioned sludge. (3) With correct vacuum but a thick, wet cake, the submergence is probably too great. (4) For low output from filters: (*a*) Increase vat submergence (*b*) increase filter speed.

Marshall (145) describes the treatment of sludge by the Porteous Heat Treatment Process in Hersham, England. The sludge treatment consists of (*a*) three high pressure heating vessels for sludge, (*b*) a heat exchanger or coacter for the recovery of heat, (*c*) two decanting vessels for the settlement of the treated sludge, (*d*) two filter presses, (*e*) one steam boiler for generating steam. The moisture content of the sludge cake produced averaged 40 per cent and the average pressing time 4½ hours.

Lumb (140) investigated the dewatering of digested humus and activated sludges. He concluded that the sludge produced from the thermophilic digestion was not amenable to mechanical dewatering. The dewatering of the mesophilically digested secondary sludges on sand beds was as slow as the undigested sludge. Only 3 ft. of wet material could be handled per year yielding a product averaging 70 per cent moisture.

Miscellaneous.—Reducing sludge disposal costs by diversification is described by Kozma (130). Some 1,500 tons of dry sewage solids annually can be disposed of by (1) Heat drying raw sludge, (2) Filtering digested sludge, (3) Disposing of liquid digested sludge on grass areas. In all cases the product is used for fertilizing purposes. The flexibility provides the most economical disposal costs depending on demands for fertilizer, cost and availability of fuel oil and the ease of digesting the sludge at Rutherford's Joint Meeting plant in New Jersey which contains varied industrial wastes. The present disposal cost is estimated at $2,460 yearly for 1,500 dry tons by heat drying 500 tons, filtering about 300 tons and drawing off the remainder as a liquid sludge.

Innovations and Aids to Practice

In a broad review, there are some items that lay claim to special classification because of their novelty. In the past year, for example, a number of innovations resulted from the search for substitutes for critical materials.

Wood and unreinforced concrete were adapted to a variety of new uses in the field of sewage disposal. Some of these are so recent in their development, that they have not yet been reported in the literature and consequently cannot be described in this review, which is concerned only with published articles. However, it should be mentioned that the Army is building wooden Imhoff tanks, some of huge size, as well as complete treatment plants, every unit of which is designed to be built with wood. Some manufacturers, likewise, have redesigned mechanical equipment in which metal parts have been replaced with wood.

One of the most recent innovations in substitution, is the use of continuous V-notched weirs made of plywood to save metal on the construction of tanks for a large army biofilter plant (177). The weir was made of ¾ × 16-in. plywood, with the V-notches made at 8-in. intervals. At this same plant wood gates, only the lifts of which are of metal, were used extensively on the recirculation wet well controls and other flow channels. The wood gates were made of ¾-in. plywood, resin-bonded, the edges filled with a penetrative seal and metal bound; the gate was given two coats of creosote paint.

Quite a sensation was created early in the year when there appeared on the market a sectional, octagonal shaped wood pipe, developed by the Armco Drainage Products Association, Middletown, Ohio (7). Fabricated from various sizes of lumber according to load requirements, and fastened together with wood dowels, this pipe eliminates completely the use of all metal. Units are shop-assembled into lengths of 12 ft. or more, which are joined together in the field into a single structure.

Wood covers and concrete ring manhole installations have been the means of saving large quantities of critical materials. At one airbase alone, this one substitution led to a saving of some 10 tons of iron (209). One of the features of design was to provide that the depth of the cover seat in the ring was equal to the thickness of the standard cast iron cover so that the wood covers could be replaced in the future with metal covers. Another interesting design for a wood manhole cover was developed in Los Angeles County, Calif. (8). Here the cover is made of laminated wood strips, fashioned in either hexagonal or semi-circular shape; wear and splintering of the wood is reduced by laying the laminated strips at 45-deg. angles to the line of traffic, applying a thin coating of emulsified asphalt—covered with dry sand or gravel to the top surface of the wood cover, and keeping the surface of the cover flush with the roadway.

Generally speaking, war creates rather than solves problems. But the genius (who must remain anonymous for the duration) who suggested the use of dried sewage sludge as a ground cover camouflage material, solved two problems. He discovered that the dark-colored sludge was ideal as a cover material to obliterate the reflecting qualities of light-colored soil exposed around the site of a newly constructed industrial plant. Some 30,000 tons of material, spread to a depth of 3 in. around the plant, was then obtained from a nearby municipal plant (6). As a result one municipality was relieved of the problem of disposing of its sludge and at the same time the material has served a most useful purpose in the war effort.

In another instance, however, war and sludge disposal were not compatible. This was the situation in New York City where the submarine menace earlier in the year made it necessary to hold the city's fleet of three seagoing sludge boats in port for ten days (4). The boats carry liquid sludge from the city's sewage treatment plants for disposal some 12 miles off shore. Eventually, the sludge boat "Navy" defied the submarine menace, but not before the sludge accumulations totaling some 4,000 tons daily were discharged in the waters of Long Island Sound.

A novel feature of one of our newest sewage treatment plants, that at San Diego, Calif., is the use of so-called "vacuators" (171). As described by The Dorr Company engineers (24) the "vacuator" is a machine devised to remove grease, scum and oil from sewers or trade wastes by vacuum flotation ahead of sedimentation. Sewage is aerated for a brief period and the aerated liquor is then subjected to a vacuum equal to several inches of mercury for a period of 10 to 15 min. The fine bubbles attach themselves to the grease or scum forming particles, causing them to rise to the surface under the influence of the vacuum.

Something unique in sewage disposal installations was the treatment plant designed to handle a 9-hour flow from the new War Department Office Building in Arlington, Va. (9). The plant was designed for occupancy of the building in the adjacent military areas during the working day only, six days a week. No precedent for a plant of this kind existed. Because it was considered essential to provide complete treatment, high-rate sprinkling filters were chosen and chlorination equipment was installed for emergency needs. The plant is designed to serve a maximum population of 40,000, on which basis the total flow was expected to be 1.2 m.g.d. A design rate of 3.2 m.g.d. for a 9-hr. period was adopted.

Little precedence existed for the design of sewage disposal facilities in the huge war production plants built during the last eighteen months. Never before have we had industrial plants of such enormous size and with such enormous number of employees, and the sanitary engineers called upon to design disposal facilities for these plants have had to contend with new problems relating to the determination of volume and character of sewage produced, as well as the variation of flow caused by "shift" operations and plumbing arrangements. Observations made on the operation of some of these plants (129) are quite revealing, as, for example, the data which shows that in factories employing skilled labor, per capita flow is considerably less than in places where unskilled workers are engaged. Also, it was shown that although an employee may spend about one-third of a day at his job, sewage production during that time on the concept of population equivalent, is considerably less than one-third.

Also of interest in connection with wartime sewage disposal practice was the use of an outfall sewer as a chlorination chamber in lieu of constructing a contract chamber for this purpose at a large army camp installation (5). About 3,000 ft. of the 5,000-ft. outfall (30-in. pipe) had a flat grade of 1 ft. per 1,000 ft. of length. It was determined that by introducing chlorine solutions at the beginning of the outfall, there would be ample admixture and contact for the 30-min. time required for the sewage flow to reach the end of the outfall sewer.

Equipment

No outstanding development in sewage works equipment marks the literature of 1942. Various periodicals publish valuable summaries of available equipment, such as *This Journal* (23), *Water Works and Sewerage* (26), *Sewage Works Engineering* (15), and *Public Works* (142). Most articles describing sewage treatment plants mention some forms of equipment. For example Hansen and Hill (103), in an article on sewage disposal in army camps, summarize the various kinds of equipment that have been used. Lingo (137), describing a plant in a Southern army camp mentions pumps, rake for removing grit, comminutors, mechanical rakes and pumps in a sedimentation tank, pumps to move sludge to digesters, mechanical agitators to break up solids in primary tanks, floating covers on digesters, exhaust fans to guard against explosive gases, and other mechanical equipment. Similar mechanization is reported by Cottingham (52) at the sewage and garbage treatment plant at Gary, Indiana, and by Mason (147) for the plant at Hammond, Indiana. In an anonymous article on sewage treatment operation (12) mechanical equipment for various methods of sewage treatment is described. A list of essential equipment for a full-time sewer maintenance crew in a large city is presented in *This Journal* (20). The list includes everything from assorted brushes to a 2½ ton truck. Decher (59) describes a 3-ton maintenance truck the equipment of which includes a radio and a generator for the operation of tools and an air blower. The vulnerability of mechanical equipment to war damage is pointed out by Devendorf and Dappert (62).

The description of interesting items of equipment is to be found in articles emphasizing other subjects. Schroepfer (197) describes a 44-in. centrifuge for sludge drying at Minneapolis, St. Paul; Fischer (79) describes a revolving distributor of special design for application to biofiltration; Hageman (96) describes difficulties met in the operation of circulating fans handling sludge vapor at Chicago West Side; and Gerdel (85) describes the gas handling equipment at Cleveland Westerly works. At Olean, N. Y., an interesting method of removing and washing grit by an air-lift system, using a home-made foot piece of ingenious design, is described by Fuller (82).

An ingenious maximum flow gage, designed by Simms at Shorewood, Wis. (25), has served satisfactorily through several storms. Grease removal equipment at San Diego is described by Phelps and Stockman (171). The magnetite filters at Minneapolis and St. Paul (197) were completed in April 1941, have passed final acceptance tests but are still under maintenance bond.

Pumping equipment is widely mentioned in the literature. Kappe (123) describes the "Scru-peller," centrifugal, sludge pump. Fischer (79) recommends the propeller type of pump for recirculating in a biofiltration plant; and Meeker (154) explains design features of sewage pumps. Hageman (96) explains some difficulties encountered in the operation of centrifugal sewage pumps, including such details as failure of bearings, wear of shafts, wear of rings, clogging and other details.

Sludge handling devices involve the most extensive mechanical equipment about sewage treatment works. Advantages of the intermittent operation of sludge collecting equipment are set forth in *This Journal* (22). The extensive mechanization of sludge collecting equipment is emphasized by Johnson (120) for Chicago Calumet, and by Hageman (97) for Chicago Southwest. Kozma (130) discusses costs involved and recommends diversification of equipment for sake of economy. Edwards (69) describes an uncommon type of equipment in the form of a sea-going vessel, used for handling sludge from the Ward's Island plant in New York City. Economy in the operation of gas engines, using sludge gas, and methods for reporting costs are described by Frazier (81). Sheets (204) describes a vacuum filter dressing rig, used at Columbus, Ohio, which saves time in the removal and replacement of cloth on the filter.

The screens in New York City are described by Donaldson (65) where the screens are used as a stop-gap between the discharge of raw sewage and effective treatment. An ingenious automatic device (22) used at Chicago North Side for the cleaning of screens uses an air-purged, differential switch of the diaphragm type, which uses a head loss device to start and to stop the screen. A time switch may also be used to operate the cleaning mechanism at any predetermined period or hour.

Stream Pollution

Abatement and Control.—A number of papers concerning the general problems of stream pollution abatement and control were published during the year. Hoak (109) presented a review of the entire subject pointing out the complexity and tremendous cost of the national stream pollution abatement problem and suggested that a program be developed only after careful examination in view of its impact on the national economy. Cutter, Greeley and Milliken (56) classified streams according to their highest use, gave a sample pollution abatement plan, summarized the responsibility of Federal and various state agencies for the New England area and suggested standards. Searles (202) discussed the types of legislation proposed in Congress and suggested that the American Mining Congress as representative of the industry continue opposition to drastic Federal regulation and work with state associations toward solution of the problem. Hall (98) described the work of Maryland in controlling the pollution of the oyster growing waters of Chesapeake Bay. Cohn (51) pointed out that the T.V.A. studies have established a new pattern in preventive sanitation. Rice (185) discussed the Indiana Stream Pollution Act of 1901 and stated that because of the attitude of the general public and industry the pollution control act was ineffective. The cooperative pollution control problems of the Potomac River were discussed by Kittrell (128) who found the major obstacles to be administrative, legal and financial rather than technical. The very serious pollution situation on the Delaware River due allegedly to the neglect of Philadelphia is reviewed by Vaughan and Wolman (227). Hanenberg (101) discussed the Grand River (Canada) sewage dilution problem and Seaton (203) reviewed the difficulties of stream pollution control in England and agreed that purity standards based on B.O.D. were desirable.

Bacteriology and Biology.—Sandholzer (193) found no significant difference in three presumptive media (standard lactose, formate ricinoleate and Eijkman) for coliform bacteria in sea water. It was reported by Stuart and his co-workers (217) that the Eijkman test like all other tests when applied to the coliform group showed no absolute lines of demarcation between the Aerobactor, Intermediate and Escherichia sections. Vaughn and Levine (228) studied a large number of intermediate coliform bacteria from various polluted and unpolluted water sources from which they conclude that these organisms may be divided into two predominant species which are closely related to the genus Escherichia. McFadden, Weaver and Scherago (152) concluded that as relatively more pectin-fermenting coliform organisms are found in water than in the feces of animals some of them are probably not of fecal origin. These authors found no means of differentiating the pectin-fermenting plant parasites of the tribe *Erwinia* from the coliform group. However, Elrod (75) found that the *Erwinia* would be classified as aberrant coliforms on the basis of their IMViC patterns and showed that they could be separated from the latter only on the basis of confirmation tests. Gieson (87) reported that operation of the treatment plant at Cleveland has effected a 91 per cent reduction of the bacterial population of the lake water, that the present effluent is cleaner than the shore water and that the bacterial content of the beaches is within the upper limits for bathing waters. Feldman and Winslow (78) also studied the effect of sewage plants in reducing the bacterial pollution of harbor waters and found that the percentage of positives for the coliform group in 0.1 ml. portions had been reduced from 39 to 14 since operation began. After operation of the plants most bathing beach stations around New Haven showed a coliform index of 3 per ml.

Lackey (133) found about 448 genera of microorganisms in a four year study of streams of the Ohio basin. Of these genera some species were extremely tolerant of environmental factors, about 20 favored highly polluted water and about as many disappeared in polluted stretches. The yellow and green flagellates were included in the latter group. Brinley (40) reported that the plankton study of the Cumberland River showed the effect of an isolated source of pollution upon a clean stream. Brinley (38) suggested the division of polluted streams into five zones upon the basis of the dissolved oxygen, the plankton populations and the probable fish population. Brinley (39) also reported that large volumes of Euglena, Trachelmonas and Phaecotus indicate heavy pollution upstream and that the presence of the algae, Chrysococcus and Cryptomonas in large numbers indicate that a stream has largely recovered from pollution.

Oxygen Demand.—Buswell and Dunlop (42) reported that while far from ideal the 5-day B.O.D. test is still the most widely used measure of organic load; and though permanganate is most widely used for the oxygen consumed test chromic acid or iodate are preferred where complete combustion is required. Johnson and Halvorson (121) used iodic acid for oxidation of organic matter claiming that the results obtained are a more reliable index of the oxidizable organic matter present than B.O.D. determinations. Moore and Ruchhoft (158) studied the effect of river mud deposits in producing an immediate demand on a deoxygenated stream and recommended the use of calculated initial dissolved oxygen values for obtaining proper B.O.D. evaluations under these conditions.

Reaeration.—Tyler (225) discussed a scheme for reaeration of a stream by artificial means. In place of conventional sewage treatment, particularly for strong wastes, the waste would be discharged into the stream after any necessary preliminary treatment and the stream would receive "accelerated reaeration" at a downstream point where the D.O. reaches critical values. Such a plan of stream aeration was investigated by the Sanitary District of Chicago a number of years ago and given up. Tyler's experiments indicate higher absorption values for bubble aeration than is indicated by activated sludge experience, where higher bubble velocities are required, and he suggests additional studies to determine the percentages of oxygen than can be absorbed by bubble aeration.

Standards.—Green (91) reported that no one standard of purity will apply to an entire state or drainage basin and stressed the importance of intelligent investigation, good basic data, and careful consideration of the problem confronting pollution control agencies. According to his report the policies of state, multi-state compact organizations and the U. S. Public Health Service all serve to emphasize the extreme care with which any regulatory body should approach the problem of standards of water purity for streams. Schroepfer (198) presented data on hourly and daily fluctuations in dissolved oxygen and B.O.D. results on a stream, demonstrating thereby the dangers of indiscriminate sampling and the lack of reasonableness of stream standards which only permit smaller changes in these criteria due to load than are apt to occur as a result of sampling errors. He pointed out the possibilities of composite and automatic sampling for stream study, discussed standards in relation to water use and reviewed the standards which have been set up by eleven authorities.

Scott (201) reviewed the work of the sub-committee on the classification of streams in New England. This committee classified waters on the basis of use as follows: Class A—drinking or cultivation of shellfish; Class B—bathing; Class C—boating, fishing, culture of seed oysters or industrial supply; and Class D—navigation or transportation of wastes. The effect of locale upon use classification was recognized and minimum quality standards for appearance, D.O. and coliform organisms were set up for each classification. The sewage treatment procedures required for various use classifications were presented. Moderate quantities of industrial water may be discharged into Class C waters without extensive treatment. No attempt to fix standards for industrial waste discharge was made. As the concern of the committee was with interstate aspects of pollution, river valleys were considered as entities regardless of state lines. The committee organization and procedures were described and appeared to be successful in accomplishing the desired ends. Weston (237) stated that the work of Mr. Scott's committee has laid the foundation for successful planning and may well form the basis of a general plan for the protection of streams throughout the country.

Surveys.—Olson, Brust and Tressler (164) reported on the effects of industrial effluents into the Lower Patapsco River area. They estimated that 100,000,000 pounds of ferric hydroxide are formed from copperas disposal in a year which has produced a marked ecological unbalance in the entire bottom area. The most severe effect of this pollution was the lowered D.O. over the general region which had an indirect deleterious effect on plankton and higher forms. Jones (122) found that unused metalliferous mine workings discharge water heavily polluted with zinc lasts into the Ystwyth River which at normal levels carried from .7 to

1.2 p.p.m. of zinc and traces of lead. The absence of fish in the stream was associated with the chemical condition of the water. King, Bean and Lester (127) reported that industrial effluent treatment successfully maintained the percentages of dissolved oxygen saturation of the Raritan River below the plant within the 50 per cent saturation limit set up by the New Jersey State Board of Health.

The North Dakota Department of Health report (182) on the Red River of the North Research Investigation is the first comprehensive survey of a river flowing north which has its most critical conditions under ice coverage during the winter. The survey covered 13 months and included the collection of hydrometric, biological, bacteriological and chemical data. The study showed that under ice coverage the dissolved oxygen in the Red River was completely depleted within a few weeks, that during the winter and summer critical periods the flows from tributaries were insignificant both from the standpoint of pollution contributed and the dilution provided; and that the pollution problem could not be solved without additional treatment of wastes entering the river. It was also found that relatively unpolluted northern streams, due to natural pollution alone, may become completely devoid of oxygen during the ice coverage period. Interesting data on long-time B.O.D. at ice coverage temperatures are included in the report. Rudolfs and Heukelekian (190) reported a study of the Raritan River covering three periods, the first (1927–28) when practically no sewage or industrial waste treatment existed, the second (1937–38) when practically all domestic sewage reached the river after treatment, and the last (1940–41) after some of the larger industries had also installed treatment facilities. The surveys show a general bacterial improvement in the river except around New Brunswick. A similar improvement was shown in B.O.D. reduction except for the section between Manville and Bound Brook. The oxygen requirements at Bound Brook doubled from 1927–28 to 1940–41, reaching a population equivalent of 171,200 for the last period. This increase was attributable to discharges between the points mentioned above and reflects the increased industrial activities. Sewage treatment has improved the river somewhat from a public health standpoint. However, as the summer 5-day B.O.D. in the stretch around Bound Brook averaged around 12 p.p.m. with dissolved oxygen values of 3 p.p.m. or less (20 to 30 per cent of saturation) further improvement is necessary to restore the river to reasonable purity.

Industrial Wastes

General.—One of the outstanding contributions to the 1942 literature on industrial waste treatment was the compilation of "Industrial Waste Guides" of the U. S. Public Health Service (162). These guides are a supplement to the Final Report to the Ohio River Commission. They summarize the available information on the wastes from all classes of industry in the Ohio River Basin.

The report contains 11 Guides each dealing with a specific industry. The industries dealt with are brewery, cannery, coal washery, coke, cotton, distillery, meat, milk, oil, paper, and tannery. The discussions in each case follow a more or less definite outline:

(*a*) Description of the manufacturing process
(*b*) Raw materials
(*c*) Products
(*d*) Employees
(*e*) Sources and quantity of wastes
(*f*) Character of wastes
(*g*) Pollution effects
(*h*) Remedial measures (treatment processes)
(*i*) Results of specific surveys
(*j*) Bibliography

Flow diagrams of the various manufacturing processes are given. These diagrams show the sources of the wastes and the average rate of flow from each source. Numerous tables have been prepared to show the average volume of waste and average analyses. These data have been compiled from articles dealing with the specific waste and from surveys made by the Service. The concentrations of the wastes are given in units appropriate to the industry. For instance, concentration in the canning industry is given on the basis of each case of No. 2 cans. In the tanning industry it is based on the hides processed.

The comparative effectiveness of various treatment processes adapted to a specific waste is discussed and some treatment plant design data are given. Cost estimates and comparisons are made where possible.

These Guides contain a large amount of authentic and essential data relating to the wastes from the industries listed above.

Another contribution to the information on industrial wastes is that compiled by Eldridge (70). The treatment of the subject in this book is similar to that used in the Industrial Wastes Guides except that it goes further into the practical application of the treatment processes to full-scale treatment.

The wastes from the following industries are discussed in detail; beet-sugar, milk products, cannery, tannery, pulp and paper, textile, meat. laundry, metal, gas and coke, chemical, brewery and distillery, and oil fields and refinery. A chapter deals with the effect of trade wastes on sewage treatment processes.

Manufacturing processes and flow diagrams are given showing the sources of wastes; average composition and flow rates are compiled; recovery processes are discussed, followed by details of treatment processes, drawings and discussions of treatment plants, expected efficiencies and cost data.

Because of the rapidly developing field of industrial waste treatment, some items have escaped the attention of the author of this book, while others have not been given the emphasis their importance demands.

Adams (1) discusses industrial waste pollution control as practiced in Michigan. The supervision of waste treatment plants is emphasized.

The results of pollution control are in direct ratio to the efforts put forth by control divisions of the State. There is a need for good judgment and cooperation in the administration of pollution control laws. The Michigan law is discussed in detail.

A survey of the industrial wastes within the East Bay area was conducted by Ramseier (179). The domestic and industrial wastes arising in this area are discharged into tidal water. The industrial wastes constitute one-third to one-half the total sewage load. A great variety of industrial wastes are found in this area such as fruit and vegetable packing, dairy products, brewery yeast, vinegar, laundry, meat packing, tannery, textiles wastes. The volume of water, the lbs. B.O.D., lbs. of suspended solids, lbs. of grease per unit of each are given in tabular form.

Eldridge (72) discusses the general subject of chemical treatment as applied to industrial wastes. The characteristics of wastes which favor the use of chemical treatment are listed. Comparisons are made between the requirements and results of chemical and biological treatment. A somewhat detailed discussion is made of the application of chemicals to wastes from canneries, paper mills, beet-sugar factories, textile mills, slaughter houses, launderies and the metal industries.

Pulp and Paper Mill.—Birchard (35) in a report of the waste committee of the Canadian pulp and paper industry has compiled a two-year bibliography on the utilization of waste in the industry. This same author (34) has prepared flow sheets of the various departments in the pulp mill, that show the amount of waste and the method by which each waste can best be utilized. The report deals mainly with the losses resulting from the sulfite process and the utilization of sulfite liquor.

Two articles appearing in Swedish literature deal with the recovery and utilization of sulfonic acids contained in sulfite liquors. Erdtman (76) gives a most excellent report of the use of certain organic bases in the precipitation of these acids. Gustavson (94) discusses the use of the lignosulfonic acids obtained from sulfite liquors as agents for the tanning of hides by the vegetable tanning process.

Pittam (173) describes an interesting process for the disposal of sulfite liquor which has been developed on a pilot plant scale at the Longview mill of the Meyerhauser Paper Co. The liquor is evaporated, the residue burned and the chemicals and the power recovered from the combustion process. If magnesium base liquors are used sufficient heat is released to supply that required for evaporation. The sulfur is collected as sulfur dioxide and the ash as magnesium oxide. These are combined to produce new cooking liquor for the mill.

The immediate or chemical oxygen demand of sulfite liquor, according to tests made by Pearl and Benson (167), is more important than the biological oxygen demand. The chemical demand is due mainly to sulfites. These cannot be oxidized by aeration unless in the presence of a catalyst and at a temperature above 50° C. Activated carbon was found to be a much better catalyst for this purpose than the metal oxides. These authors state that the biological oxygen demand is readily satisfied by the normal rate of oxygen absorption by the sea water in the Pugent

Sound district where the tests were made. This does not necessarily apply to other localities or conditions.

A study of the quantity of pulp lost and the resulting pollution from ground wood pulp mill white water was made by Ahrledter (2). The loss in German mills was estimated at 90,000 to 110,000 tons per year. Sedimentation or flotation using such coagulants as alum, lime and sodium aluminate are recommended for fiber recovery.

Poor and Whitenight (175) have investigated the use of pure fatty acid soaps in combination with alum for the removal of fiber and clay from white water by flotation. (The Sven-Pedersen flotation save-all makes use of an animal glue for this purpose.) The effectiveness of the soaps in the clarification of the water increased with the length of the carbon-atom chain of the soap molecule up to 14 carbon atoms.

Studies on the wastes produced by the conversion (de-inking) of old-paper stock are discussed by Eldridge (71). This waste contains fibers, clay, ink, casein, starch and other material removed from the old papers. Lime was found to be the most effective coagulant. The optimum dosage was shown to be about 4 pounds per 1,000 gallons. The presence of a high concentration of casein in the waste inhibits coagulation. In this case the waste may be diluted with white water prior to the application of the coagulant.

Metal Industry.—The disposal of acid wastes has received considerable attention during the past year. War industries have increased the use of acid pickling liquors and the difficulties encountered in their disposal.

Woefle (242) reports increasing interference by a steel company's acid liquors with the operation of the Dunkirk, N. Y., sewage treatment plant. The low pH produces a very sticky sludge and necessitates the addition of alum prior to dewatering on sludge beds. Corrosion of metal parts has also been troublesome. Provision is being made to pretreat the liquor by neutralizing with lime. The sludge and liquor will then be discharged to the treatment plant.

Similar difficulties are reported by Snyder (211) at the Massillon, Ohio, municipal plant. Serious cases of corrosion in pump cases, flight chains and other metal parts have been observed. A brick-lined trunk sewer did not show the effects of the acid and iron wastes.

Many methods are proposed to correct these difficulties. Most of them involve the use of lime for neutralizing the acid. Smith (208) suggests the use of lime sludge from lime-soda water softening plants or the lime from hydrocarbon producers.

Metals and cyanides are an increasing factor in municipal sewage plant operation. Jenkins and Hewitt (119) state that the presence of as little as 2 p.p.m. of chromium reduces nitrification in an activated sludge plant. Ten p.p.m. completely stops nitrification.

Barnes and Braidech (31) have perfected a new method for the removal of metals (copper, nickel and chromium) and the destruction of cyanides in wastes from metal plating processes. The treatment process is patented. The authors have found that neutralization of these wastes with lime does not effectively remove these metals. The effluent from the neutralization process inhibited sludge digestion at the Meadville, Pa., sewage treatment plant. Studies showed that the toxic action was caused by chromates and precipitated copper hydroxide particles which were not removed by sedimentation in the neutralizing plant. The new process consists of passing the waste through a contact bed of scrap iron to reduce the chromates and to produce complex metal cyanides. The waste is then neutralized with lime, coagulated and settled. The sludge is lagooned. This is a timely article, since the war-industries have created many similar problems in municipal plants.

Acid industrial waste problems in Southwestern Pennsylvania are discussed by Morgan (160). The major problems in this area are due to acid mine drainage and spent pickle liquors. It was estimated that the bituminous coal mines discharged between 10 and 18 million pounds of wastes as sulfuric acid daily. Typical analyses of coal mine drainage are given. This drainage particularly affects water supplies by increasing the hardness and iron content. The most practical method of reducing the pollution caused by these wastes is by sealing abandoned mines. Acid pickling liquors are neutralized or lagooned. No details are given of the methods used.

Recovery of ferrous sulfate from pickling liquors, according to the report of Gehm (84) is not economical because of a limited market for this material. A method is given for the production of sodium sulfate (Glauber's salt) and the recovery of the iron from the liquor. A salt of high purity was obtained. Another process was described in which ferric chloride and calcium sulfate were produced. These processes serve to increase the utilization of pickle liquor by increasing the market for the products. Utilization as a method of disposal for this waste material is much more feasible than to discard the material after neutralizing the acidity.

The iron and sulfuric acid contained in pickling liquors are two of the cheapest industrial materials available in the United States. This fact is given by Van Antwerpen (226) as the reason for the delay in building recovery plants for this waste. The author describes a process (Ferron Process) for the production of a construction material from pickle liquor. One commercial installation is now in operation. Some of the products manufactured are shingles, insulating board and acoustical facings. The market for these products must be developed before the use of the process can be enlarged to any great extent.

Eliassen and Sawyer (74) reported on a method of separation of cutting oil wastes by chilling the liquid. Dropping the temperature of the waste from 200° F. to 120° F. decreased the ether soluble material from 104,000 p.p.m. to 10,000 p.p.m. On further decrease of the temperature to 80° F. the ether soluble material decreased to 264 p.p.m. The liquor obtained after the separation of the oil has a high alkalinity. Experiments on acidulation showed that best coagulation was obtained by decreasing the pH value to 5–6. The cost of the acid was, however, high.

Laundry Wastes.—Wastes from laundries may be effectively treated by chemical precipitation, according to the report of Snell and Fain (210). Alum and sulfuric acid are used as precipitants. Wastes amounting to about 60,000 gallons per day required 360 p.p.m. alum and 144 p.p.m. sulfuric acid. The chemicals and waste were mixed in a baffled channel and settled in a 30,000 gallon tank.

McCarthy (150) reports the results obtained by coagulation of laundry waste solids by using ferric sulfate, alum, alum and sulfuric acid and ferric sulfate and sulfuric acid. The same author treats laundry wastes on a trickling filter at the rate of 1 m.g.a.d. Grease removal was about 87 per cent and no accumulation of grease on the filter was observed unless the rate of application was increased above 1.5 m.g.a.d.

Tannery Wastes and Sewage.—Plans for the enlargement of the Fond du Lac municipal treatment plant to accommodate garbage from the city and the tannery wastes from the Rueping Leather Company are reported by Donohue (64). The alkaline wastes from the tannery cause a floculation of the sewage solids which has resulted in an increase in the removal of these solids. The plant is designed for primary treatment only. The major problem is sludge disposal.

Chemical Industry.—A report of the first year's operation of the treatment plant of the Calco Chemical Division is made by King, Bean and Lester (127). This plant has been described in detail in the March, 1941 issues of *Chemical Industries* and *Chemical and Metallurgical Engineering.* The treatment problem was one of the most complicated to be encountered in the trade waste field and those to whom the problem was delegated had little, if any, precedent to guide them in the selection of the processes and in the methods of control.

Wastes are produced from the manufacture of 725 different products. It was necessary to treat some of these wastes at their source. The effluents from the pretreatment processes were combined with the other wastes, the acidity was neutralized and the combined wastes were settled in a lagoon. The lagoon effluent was aerated prior to its discharge to the Raritan River.

This neutralization is an example of the use of a waste in the treatment of a waste. About 20 tons per day of lime slurry ($CaCO_3$) from the John-Manville Co. is used in the process.

Meat Packing.—The pork packing plant of the Tobin Packing Co., Ft. Dodge, Iowa, have installed a grease-recovery system to recover the grease previously lost by way of the liquid wastes. Gilman and Hartman (138) show the plan of this installation and give an excellent discussion of the method of operation. The present demand for fats has made such a system profitable even at a construction cost of $70,000.

Wastes from the gut hasher and meat processing departments are much higher in grease content than the main factory wastes. These high-concentration wastes are given a preliminary flotation treatment in a separate compartment before they join the main waste flow. The main waste is comminuted, aerated and passed through a settling and flotation tank. Grease is removed to a well and pumped to rendering tanks.

The articles show data relating to the effect of chlorine on grease flotation. This is a timely report in view of the emphasis placed on the conservation of fats for explosive manufacture.

Milk Products.—Development in industrial waste treatment as represented by the "oxidized-sludge" and "regenerative digestion" plant of the Mead-Johnson Co., Zeeland, Michigan, is reported by Mallory (141) and Eldridge (73). The oxidized-sludge process is the conventional activated-sludge process under a mathematical control developed by Mallory. Using this control method Eldridge reported the plant was able to withstand shock loads consisting of applications of acid whey, as well as a wide variation in applied loadings without an apparent effect on the effluent. Sludge bulking has not been encountered. This method apparently gives positive control of the activated sludge process for operation and plant design.

Regenerative-digestion is an anaerobic process in the initial stages, followed by aeration. The digestion is carried out in high- and medium-temperature zones with recirculation of activated material between the zones. Air is used to control the acid concentration which under the usual anaerobic condition may become sufficient to retard the reactions. The process is used at the Mead-Johnson Co. for the treatment of acid whey, cheese washings and excess oxidized sludge.

A report of an extensive study of milk-products factory waste treatment was made by the Water Pollution Research Board (England) (234). The data presented were collected over a period of about five years from studies made on both a laboratory and plant-scale basis. The publication starts with a general discussion of milk wastes and methods by which factory management may reduce the strength of wastes by careful operations. Laboratory studies include the use of fermentation, chemical precipitation, biological filtration and activated sludge.

Large scale studies were made on two biological filters used in series. The apparent optimum loading to these filters was 0.4 pound per cubic yard of filter media. Coke, ¾ to 1½ inch, was used as media. Ponding of the filter was experienced. Mixtures of whey washings and milk washings were also applied to these filters. Successful results were obtained if the waste B.O.D. applied to the filter was between 200 and 300 p.p.m. This is a very low strength waste and would not be obtained under present factory operating conditions in the United States, unless large volumes of water were used.

Full-scale activated sludge experiments indicated that long aeration periods (24 to 36 hours) are necessary if high concentration wastes (350 to 700 p.p.m. B.O.D.) were to be successfully treated. Temperature was said to have a very definite effect.

A considerable study was made of the organisms present on the filters and in the aeration tank mixed-liquor from the activated sludge process.

Distillery Wastes.—The so-called "still slop" from whiskey distilleries is one of the strongest of the organic industrial wastes. These slops have solids contents varying from 4 to 7 per cent and B.O.D. values from 20,000 to 40,000 p.p.m. Wallach and Wolman (233) discuss some of the methods used commercially for the recovery of the organic material from these wastes and suggest a method of coagulation as an aid to the removal of colloidal material by vacuum filtration. Considerable data were presented on laboratory studies of this method, but, as yet, no larger scale trials have been reported. The better coagulants for the purpose are lime and sulfuric acid, lime and phosphoric acid, or calcium acid phosphate.

Bonacci and Rudolfs (37) report the results of an extensive laboratory study of the effect of electrodialysis on the chemical and biological treatment of distillery and beer slops. These results show that electrodialysis alone does not cause an appreciable reduction in the oxygen consuming properties of the waste. The process apparently assists chemical coagulation giving higher removals with lower applications of the coagulant. The authors also show that preliminary electrodialysis materially aids biological treatment and report reductions of from 90 to 93 per cent in the oxygen consumed value of the waste by this combination of treatment processes. The function of electrodialysis is the removal of the ions from the colloidal material.

Textile Wastes.—Kier liquor is one of the stronger wastes of the textile industry. The kiering process is used to clean cotton for processing. It consists of treating the cotton with a strong solution of caustic soda and soda ash. The kier wastes are very alkaline and contain a considerable amount of organic material removed from the cotton. This waste as it is washed from the kier vats has a B.O.D. varying from 2,500 to 4,000 p.p.m.

Porges, Horton and Gotaas (176) have made a pilot plant study of the treatment processes adapted to this waste. Chemical treatment was attempted using copperas, copperas and lime, and alum in both the batch and continuous-flow processes. B.O.D. removals of about 85 per cent were obtained. The batch process was preferred because it allowed better control. The authors have expressed the opinion that, since settling is poor in a waste of high concentration of solids such as kier waste, dewatering on sand beds or a vacuum filter is more effective.

Cannery Wastes.—Black (36) reports the effect of natural purification of corn cannery waste in lagoons. The waste is first passed through a 40 mesh screen, treated with sufficient sodium nitrate to supply oxygen equivalent to about 20 per cent of the B.O.D., and stored in the lagoons. The nitrate serves to control odors. Natural purification is said to have a marked effect on reducing the B.O.D. of the waste.

Sanborn (192) reviews in a general way the treatment of cannery wastes. Waste screening is an essential part of all canning operations. Chemical precipitation is the most generally used treatment process and the batch process is favored over continuous flow. Biological processes are largely confined, to date, to experimental filters. Lagooning is used under circumstances where odors from the ponds are not likely to become a nuisance. Sanborn estimates the cost of a chemical treatment plant for a two-line cannery as about $3,000. Operating costs are about 1 cent per case of No. 2 cans.

The peel from citrus fruit canning is dehydrated for the production of cattle feed. Prior to dehydration, the waste is pressed to remove as much juice as possible. According to Nolte, Von Loeseche, and Pulley (161) over 35 million pounds of sugar, 2.5 million pounds of protein and 4 million pounds of pectin are contained in the waste juices from citrus canning in Florida each year. The authors discuss the partial recovery of the value of these materials by the manufacture of yeast and industrial alcohol from the waste juice. The cost of the manufacture of alcohol from this waste is about two-thirds of that of alcohol from blackstrap molasses due to the lower cost of raw material. The production of yeast lowers the B.O.D. of the waste juice from between 40,000 and 65,000 p.p.m. to between 3,000 and 10,000 p.p.m.

Castro (45) reports that cannery wastes at the sewage disposal plant caused the solids to float in the sedimentation tank. When the cannery wastes and the sewage are settled separately in the laboratory, neither of them rises to the top. When these are mixed, the acidity of the mixture increases and gas is produced in the sewer, resulting in the flotation of the solids in the sedimentation tank. The addition of chlorine to 80 per cent of the demand has effectively stopped the flotation of solids by reducing the activity of the organisms.

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SEWAGE TREATMENT BY FLOTATION *

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Sanitary engineers, chemists, and biologists have long been investigating sewage treatment methods with the aim of reducing the time required for treatment without reducing the degree of treatment. Recent improvements in the activated sludge process and the development of the high rate filter have been steps in this direction.

Sewage flotation is a process for removing suspended and colloidal solids from sewage. This process consists of buoying the sewage solids to the surface by means of air bubbles where the solids can be readily removed. The purpose of this study was to determine if flotation, as a process for sewage treatment, might make possible the lowering of required treatment time without reducing the quality of treatment, thus permitting the use of lower cost plants.

The literature on the use of flotation as a means of sewage treatment is extremely meagre. However, there is much literature available on the use of flotation for mineral separation, in fact, mineral flotation has been practiced since 1860 when the first patent was granted to William Haynes.

Imhoff and Fair (7) recommend and show plans for the flotation of grease from sewage and indicate possible uses of flotation in sewage treatment. The flotation principle has been applied experimentally to sludge treatment with the use of acid and/or heat.

Flotation has been used for the recovery of fiber from paper mill waste and Karlstrom (8) has adopted the principle in his patent for a paper mill waste flotation device. The removal and recovery of dye wastes by flotation has been extensively studied by various workers of the Textile Foundation (3), (4), (5), (6), (9), (10). Included in this material is considerable work on the basic principles of flotation.

Flotation and Flotation Reagents

Flotation of suspended and colloidal solids in sewage is accomplished by the attachment of the solids to rising air bubbles which buoy the solids to the surface where a froth or foam is formed. This froth, which is composed of air bubbles, solids, and a small amount of liquid, is removed.

To facilitate the attachment of the solids to the air bubbles and the formation of a froth in which the solids can be removed it is necessary to add a flotation reagent. Flotation reagents are mainly heterpolar organic compounds containing hydroxyl (OH), carbonyl (CO), nitrile (CN), carboxyl (COOH), or amine groups (NH_2) in the molecule. These compounds reduce the surface tension permitting the formation

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of a froth of such stability as to hold the solids and permit their removal. The concentration of the flotation reagent at the liquid gas and solid interfaces promotes attachment of the particle to the air bubble. As an explanation of this phenomenon, Bosqui (2) suggests that the polar part of the flotation agent reacts with the particle and the nonpolar part is oriented outward from the particle attaching to the air bubble.

Classification of flotation reagents is difficult because of their complex character and because of the lack of fundamental information concerning them. Gaudin (6) divides flotation reagents into two main groups:

1. Frothers, having one polar (hydrophilic) and one non-polar (hydrophobic) portion in each molecule. Both of these affinities are satisfied if the molecule is located at the liquid-gas interface (bubble wall) where the polar portion is in the water phase and the non-polar portion is in the gas phase. Hence the air bubbles formed under the water surface are covered with a monomolecular film of frother molecules. This film prevents the air bubbles from coalescing when they come in contact with each other, thus permitting the formation of a froth.

2. Collectors are similar to frothers in that they have polar and non-polar parts in the molecules. Here, however, the polar portion reacts with or is adsorbed onto the solid particle to be removed. The non-polar portion, being hydrophobic, has an affinity for the gas phase and concentrates at the liquid gas interface.

The collector type of flotation reagent may collect the solids as well as form a froth.

A large number of flotation reagents are now being used for various specialized mineral flotation needs. Many of these are selective in nature, that is, they will float only certain compounds or substances.

Experimental Procedure

In order to determine which of several types of flotation reagents might be most suitable for sewage flotation, it was found necessary to make preliminary tests with about twenty different reagents. These tests were made on a batch basis by aerating sewage with a carborundum bulb in a one-liter graduate cylinder. Suitability of the reagent for sewage flotation was based on the efficiency of removal of biochemical oxygen demand, bacteria, total suspended solids, and the amount of reagent required.

The results of the preliminary studies clearly showed that most of the reagents used were not satisfactory for sewage flotation, although a few showed possibilities and one reagent, DP 243, appeared to be quite efficient and was used in studying sewage flotation in greater detail. DP 243 is a heterpolar lauryl amine hydrochloride which has strong frothing and collecting properties over a wide pH range.

In analyzing the problem of sewage treatment by flotation the following points presented themselves for consideration: (1) Amount of

DP 243 reagent required for flotation. (2) The effect of floating various strengths of sewage with a given dosage of flotation reagent. (3) Time required for flotation. (4) Effect of adding coagulants and other chemicals. (5) Bactericidal effect of the flotation agent. (6) Effect of pH on the flotation of sewage with DP 243. (7) Digestibility of floated sludge. (8) Effect of certain industrial wastes on the process of flotation. (9) Applicability of the flotation process to a continuous flow basis.

The first eight of the above points were studied by means of batch flotation. One-liter graduates were filled to the liter mark and placed in a shallow pan which caught the overflowing froth. DP 243, prepared in 1 per cent aqueous solution, was added to the sewage and the mixture was stirred. Air was introduced at the bottom of the liter graduate through carborundum diffuser bulbs, as shown in Fig. 1. Aeration was allowed to continue until a stable froth ceased to be produced, requiring from 15 to 25 minutes.

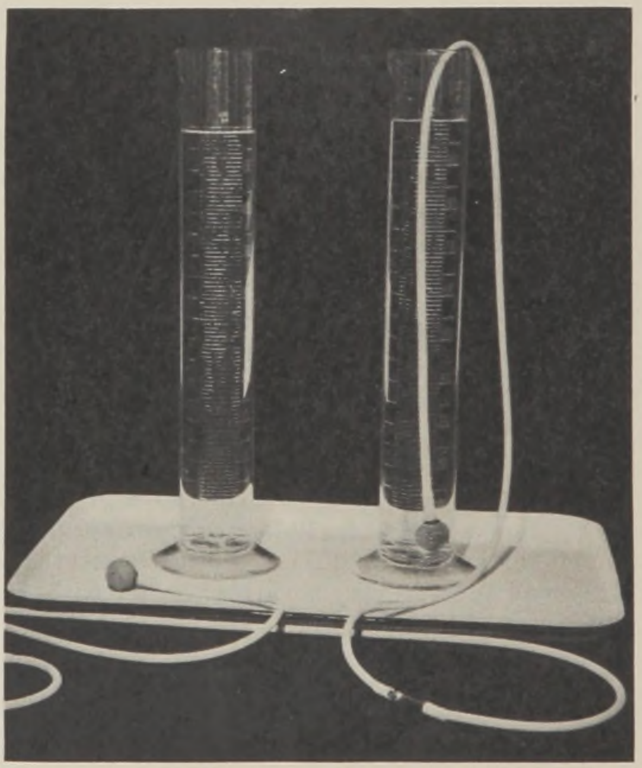

Fig. 1.—Photograph showing the apparatus used in the small batch flotation studies.

The apparatus shown in Fig. 2 was used for studying sewage flotation on a continuous basis. Three flotation cells, each 60 cm. long and 7 cm. in diameter, were used in series. The mixture of sewage and flotation reagent was stirred in the crock shown in the upper left and syphoned at a fixed rate into the first cell. The sewage or effluent was introduced 7 cm. from the top of each cell and drawn off from the bottom. Aeration was provided by placing carborundum diffuser bulbs in the bottom of the cells. The procedures of Standard Methods for the Analysis of Water and Sewage (1) were used for all the tests. Seeded dilution water was used for the biochemical oxygen demand determinations.

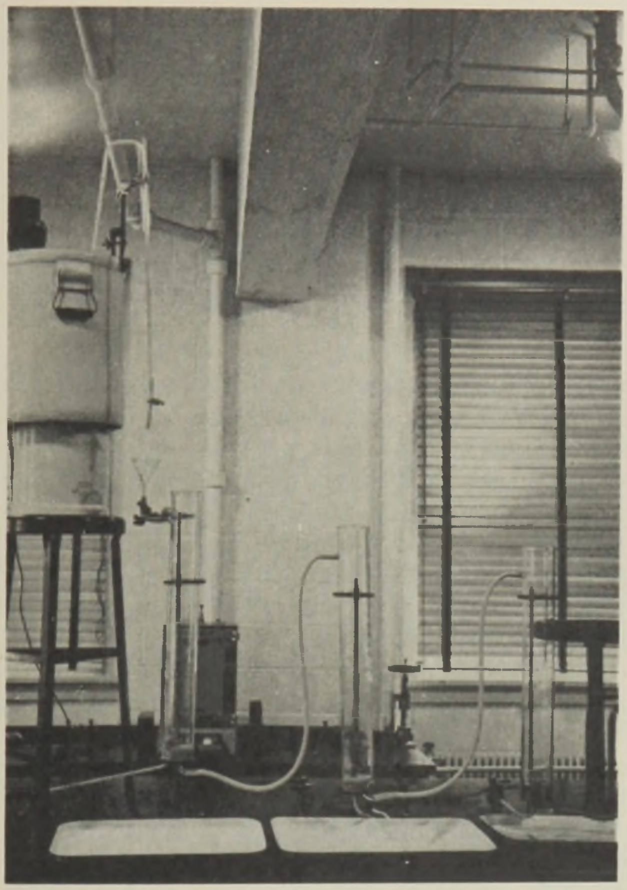

FIG. 2.—Photograph showing continuous flow apparatus.

The results obtained in the laboratory were confirmed with pilot plant studies for which a flotation cell 12 in. in diameter and 5 ft. long was used.

RESULTS

Batch Flotation.—Table 1 shows results which are typical of one-liter batch experiments in which different sewages were floated with varying amounts of reagent. Sixty parts per million of flotation reagent gave the smallest residual B.O.D. (82 per cent removal), the residual B.O.D. increasing slightly with larger dosages. However, larger dosages reduced the number of bacteria remaining, largely due to the bactericidal effect of DP 243. The suspended solids determinations were not made on the effluent from the 60 p.p.m. dosage of this experiment. However, other experiments showed the residual B.O.D. to be lowest when only sufficient flotation reagent had been added to remove the suspended solids and thus produce a clear effluent.

TABLE I.—*Flotation Efficiency for Various Dosages of DP 243 Applied to Raw Sewage*

DP 243 Added p.p.m.	B.O.D. p.p.m.	Bacteria No./ml.	Total Solids			Suspended Solids			Dissolved Solids		
			T	M	O	T	M	O	T	M	O
0	196	1,800,000	356	128	228	146	20	126	210	108	102
20	167	1,500,000									
40	67	200,000									
60	35	19,000									
80	38	5,000									
100	50	2,100	156	98	58	0	0	0	156	98	58

T = Total. M = Mineral. O = Organic.

The dosage of flotation agent required to remove the suspended solids usually varied from about 60 to 80 p.p.m. for different sewages, depending on the amount of solids present and condition of sewage. Experiments showed that within the usual range for strengths of sewage the flotation reagent yields more efficient results, in terms of the amount of suspended solids removed with a given dosage, on sewages having a high suspended solids content. Strong sewages require only slightly larger dosages of flotation agent to remove the suspended solids than are required for weak sewages.

The flotation reagent will not remove large pieces of paper and other large solids. It was found that the solids remaining in sewage after a settling period of 10 to 15 minutes were readily removed by the flotation reagent and that longer preliminary settling was of no apparent advantage.

The flotation reagent will remove practically all of the B.O.D. due to suspended solids, and most of the B.O.D. due to colloidal solids but has no appreciable effect on the dissolved B.O.D. Various experiments showed the flotation reagent capable of removing from 50 to 85 per cent of the B.O.D. depending upon how much of the B.O.D. is in a dissolved form.

Experiments on one-liter batch samples showed that aeration periods greater than 20 to 30 minutes did not improve the removal of B.O.D. or bacteria, and 15 to 25 minutes aeration, depending on the rate of aeration, was usually sufficient to remove the suspended solids. After 15 to 20 minutes aeration the dissolved oxygen in the effluent was just a little below saturation.

The addition of coagulants, such as iron salts and filter alum, had no appreciable effect on the clarification produced by the flotation reagent and the results indicated that the reagent has sufficient collecting powers without the use of a coagulant. Likewise additions of activated sludge did not improve clarification over that obtained by the flotation reagent alone.

Bactericidal Effect of the Flotation Agent.—The experimental results in Table I and as well as results of other experiments showed that flotation effected a bacterial reduction of from 99 to almost 100 per cent and indicated that the flotation reagent had bactericidal properties. To confirm this a test was made using two beakers each containing 800 ml. of the same sewage. One was used as a control and to the other was added 60 ml. of DP 243. Bacteriological samples from each were plated out on nutrient agar at definite intervals and incubated at 37° C. for 24 hours for counting. Figure 3 shows the results and indicates that

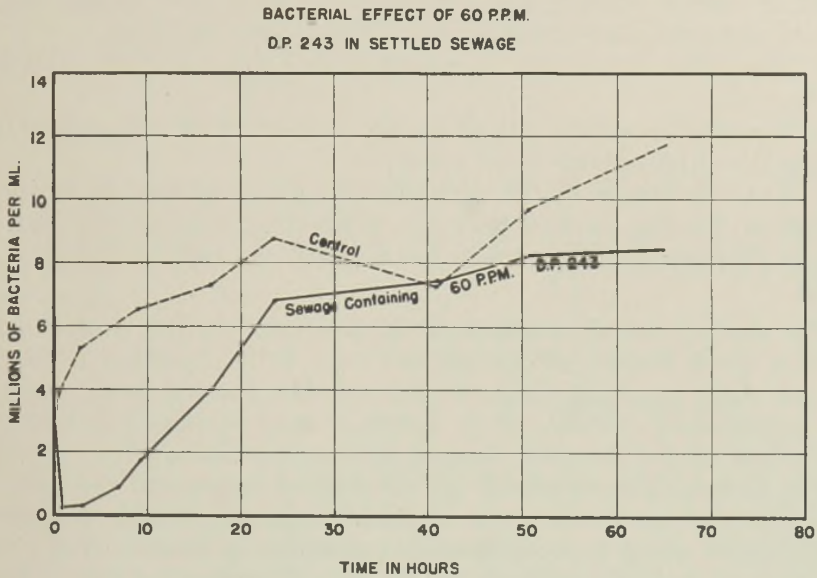

FIG. 3.—Bactericidal effect of 60 p.p.m. DP 243 in settled sewage.

DP 243 has bactericidal properties but after a few hours its bactercidial effect is evidently dissipated and the remaining bacteria in the presence of ample food supply multiply and eventually approach the count of the control sample of sewage.

Effect of pH on Flotation.—The effect of pH on flotation was determined by keeping constant all factors such as rate of aeration, strength of sewage, and flotation reagent dosage. The pH of the sewage was adjusted by adding sulfuric acid or sodium hydroxide.

The results showed that DP 243 gave best flotation in the neutral pH range 6.0 to 8.0 but was not affected much by acid conditions. However, as the pH approached 9.0 the reagent appeared to lose the greater part of its frothing power and collecting powers. In most instances sewage with an initial pH of 6.6 to 8.0 was raised to a pH of about 8.1 during the process of flotation. A few of the flotation reagents which did not exhibit satisfactory collecting powers in sewage near a neutral pH were found to clarify the sewage very well if the pH of the sewage was lowered to pH 2.5.

Digestion of Floated Sludge.—The following two experiments were conducted at 30° C. to determine the effect of the flotation reagent on the digestibility of the floated sludge: (1) A sludge mixture containing 75 per cent digested seed sludge and 25 per cent fresh floated sludge by volume. (2) A sludge mixture containing 50 per cent digested seed sludge and 50 per cent fresh floated sludge by volume. Gas production was observed for a period of 20 days. The mixture containing 75 per cent seed and 25 per cent fresh floated sludge sample digested very well, as is evidenced by the following results:

1. The quantity of evolved gas per gram of volatile solids compared favorably with usual values for seeded raw sludge and the evolved gas contained a minimum of 70 per cent methane.
2. The pH of the sludge increased from 7.2 to 7.5 during the digestion period.
3. The sludge solids settled to the bottom of the digestion bottle leaving the supernatant liquid on top.
4. The calculation of the unimolecular curve of best fit to the gas production results showed that gas production was 80 per cent complete in 20 days and the constant indicating the rate of digestion was 0.0485.

The sludge sample containing 50 per cent seeded sludge and 50 per cent fresh floated sludge showed very little digestion in 20 days. The physical characteristics of this sludge showed poor digestion. The experiments indicate that sufficient seed sludge will buffer the toxic effect of the flotation reagent and permit satisfactory digestion.

The hydrophobic character of the floated solids and the high rate at which they settle when not attached to an air bubble suggest the possibility of using vacuum filters for dewatering floated sludge.

Effect of Industrial Waste on Sewage Flotation.—Table II shows the results of experiments on the flotation of a paper mill waste and

TABLE II.—*Treatment Efficiencies Obtained by Flotation of Industrial Wastes With 100 p.p.m. DP 243 Flotation Reagent*

Type of Treatment	B.O.D. p.p.m.	pH	Total Solids			Suspended Solids			Dissolved Solids		
			T	M	O	T	M	O	T	M	O
Raw paper mill waste	57	6.3	1524	652	872	586	480	106	938	586	766
Floated 100 p.p.m. DP 243	15	6.9	854	358	496	12	0	12	842	358	484
Raw sewage with dye waste	320	7.9				222	28	194			
Floated 100 p.p.m. DP 243	160	6.6				4	0	4			

T = Total. M = Mineral. O = Organic.

of a sewage containing a large quantity of textile wastes. The final effluent of the paper mill waste experiment was very clear and had only a few fibers left in suspension. Seventy-four per cent of the B.O.D. was removed leaving a residual of 15 p.p.m. and 98 per cent of the suspended solids were removed.

While 99 per cent of the suspended solids in the sewage containing textile mill waste was removed, only 50 per cent of the B.O.D. was removed, leaving a residual B.O.D. of 160 p.p.m. Since much of the B.O.D. in textile waste is in a dissolved form these results give further evidence that the flotation agent does not remove the dissolved B.O.D.

TABLE III.—*Flotation of Domestic Sewage Containing a High Textile Dye Content. Continuous Flow Process Used With Variable Dosage of DP 243*

Dosage of DP 243—p.p.m.	B.O.D. in p.p.m.			Suspended Solids in p.p.m.			Remarks
	Initial	Final	Per Cent Reduction	Initial	Final	Per Cent Removal	
Sewage I							
0	350	—	—	224	—	—	
80	350	150	57	224	7	97	Slight yellow color in effluent
100	350	150	57	224	3	98.7	Slight yellow color in effluent
Sewage II							
0	450			280			
80	450	160	65	280	10	96.5	Slight yellow color

Continuous Treatment of Sewage by Flotation.—Table III shows the results obtained for the continuous treatment of two different sewages in the flotation apparatus illustrated in Fig. 2. These sewages contained large amounts of textile wastes. It is seen that the suspended solids removal is excellent but the B.O.D. remaining is high due to the dissolved unstable material from the textile waste in the two sewages.

Table IV shows the results obtained for a continuous flotation experiment in which the total retention time for treatment in the three

TABLE IV.—*Sewage Flotation as a Continuous Process Using 80 p.p.m. DP 243 and a Variable Retention Period (Settled Sewage)*

Total Retention Time Minutes	B.O.D. in P.P.M.			Suspended Solids in P.P.M.			pH	Remarks
	Initial	Final	Per Cent Reduction	Total	Mineral	Organic		
0	212	—	—	162	20	142	6.9	Settled Sewage
15	212	69	68	6	0	6	8.2	Froth in all cells
24	212	69	68	3	0	3	8.2	Froth in first two cells
32	212	67	69	9	5	4	8.2	Froth in first two cells

flotation cells was varied. These results show no appreciable difference in B.O.D. and suspended solids removal for retention times longer than 15 minutes. The suspended solids and B.O.D. removals are similar to those obtained with similar sewage on a batch flotation basis. Experiments on continuous flotation showed that when the total retention time in the three cells was longer than 20 minutes clarification was completed in the first two cells; no froth developed and no solids were removed in the last cell.

After the froth is removed it coalesces quickly producing a liquid from which the solids settle rapidly due to their hydrophobic character. Experiments were made to determine if the supernatant from the sludge retained sufficient quantities of the reagent to have floating properties. It was found with continuous treatment that when the excess supernatant was returned to the influent it was possible to reduce the flotation reagent dosage by 20 to 25 per cent of the dosage required when the supernatant was not returned to the influent.

Discussion

The results indicate that the flotation process for sewage treatment compares rather favorably with other processes for sewage treatment. The consistent values of 97 per cent to slightly less than 100 per cent removal of suspended solids and bacteria indicate that on the basis of these criteria for efficiency of sewage treatment, flotation is superior to the usual processes of sewage treatment, since it is rarely possible to obtain this degree of removal by the common processes. However, from the viewpoint of B.O.D. removal it is inferior to the biological processes and yields results in the general range of those obtained by chemical precipitation, namely, 50 to 85 per cent removal of B.O.D. While the per cent removal of B.O.D. by flotation is in the range ascribed to chemical treatment it appears that the B.O.D. removal will average a little higher by flotation than by chemical precipitation. The B.O.D. removal appears to depend on the portion of the total B.O.D. of a sewage that is in a dissolved form, since flotation does not remove much of the dissolved B.O.D. Possibly further treatment of effluents from the flotation process which have too high a B.O.D. could be effected by biological processes.

Much more investigative work must be done before economic and cost data can be discussed quantitatively. However, there are points affecting cost which are worthy of mention. The flotation process will not remove large pieces of paper and other large suspended solids but the flotation process will clarify a sewage which has settled for 15 minutes as satisfactorily as if it had been settled for two hours. No secondary settling is required following flotation. This indicates that a total capacity somewhat larger than 30 minutes sewage flow would be required for a flotation plant as compared with a capacity equivalent to 9 to 10 hours sewage flow for an activated sludge plant (1½ to 2 hrs. primary settling, 6 hrs. aeration time, and 1½ to 2 hours final settling). As compared with chemical treatment, flotation would not require as large retention capacity but would require the use of compressed air. However, the sewage effluent from the flotation process would contain considerable dissolved oxygen.

The cost of the flotation reagent is the most important factor and at the present time it is much too expensive to be economically used in sewage treatment. If flotation reagents of the lauryl amine type were produced in large quantities their price might be much lower. Since only a very limited number of flotation reagents were used in this study, there is also the possibility of flotation reagents being tried, which would be more efficient and less expensive than DP243.

While no data are available on the necessary rate of aeration for the flotation process, laboratory studies indicated that the rate of aeration should be sufficient to provide good agitation. Pilot plant studies on a batch basis indicated that when agitation was accomplished by mechanical stirring less air was required because the bubbles in following a longer spiral path have greater opportunity for contact with solids. It is evident that the depth of the flotation tank would be a significant factor in determining the amount of air required since deeper tanks would provide greater chance for more particles of solids to collect to a rising air bubble.

It is not believed that DP 243 is the most satisfactory flotation reagent for sewage clarification. It yielded the best results of the various reagents investigated so was used as the reagent for studying sewage flotation in more detail. It is quite possible that a flotation reagent can be developed which would be more efficient for the clarification of sewage. Flotation reagents which are specific for the flotation of certain minerals have been developed and specific reagents for sewage flotation may be possible.

Summary and Conclusions

Typical results of a preliminary investigation have been presented which show the possibility of sewage treatment by a flotation process in which chemical flotation reagents were used to promote flotation. The authors do not claim that a flotation process is at present a satisfactory process for sewage treatment but show experimental results which are believed to indicate that the flotation method may have possibilities in the field of sewage treatment which justify further research.

In view of the fact that flotation removes little if any dissolved solids, it would seem that further treatment would be desirable when high B.O.D. removal is required. A sand or magnetite filter would probably produce good results, especially since the suspended solids are extremely low and the effluent almost saturated with oxygen.

The results of this investigation permit the following conclusions to be drawn:

1. Of the several flotation reagents investigated DP 243 showed the most promise.

2. The optimum dosage of DP 243 for flotation of domestic sewage is usually in the range of 60 p.p.m. to 80 p.p.m.

3. The retention time necessary for clarification of sewage by flotation appears to be around 15 minutes. (After 15 minute preliminary settling period.)

4. Suspended and colloidal matter is readily removed from sewage by flotation.

5. DP 243 does not remove much of the dissolved organic matter in the process of sewage flotation.

6. Sludge removed with DP 243 is readily digested if properly seeded.

7. Chemical coagulants used in conjunction with DP 243 do not appreciably improve clarification over that obtained with DP 243 alone.

8. Strong bactericidal power is exhibited by DP 243.

9. DP 243 showed greatest efficiency when the pH of the sewage is in the range 6.0 to 8.0.

10. Paper mill wastes can be clarified by flotation.

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Discussion

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The adaptation of a well-established metallurgical process to the treatment of sewage has been attempted by the authors. For years, the principles and practices of the metallurgical field have been applied with success to the problems of the sanitary engineer. This is particularly true of mechanical equipment which has been developed by manufacturers who are engaged in both fields. Among these may be mentioned the development of the water and sewage clarifier mechanisms from ore thickeners; grit washers from the rake, jig, and screw-type or classifiers; rotary sewage distributors from the rotating distributors of cyanide solution in leaching vats for gold ore; sludge elutriation from the counter-current washing of ores; sludge filters from the vacuum filters used to dewater ores; and sludge driers and incinerators from ore roasters of the rotary or multiple-hearth type.

Reference to the patent literature indicates that in 1920 C. L. Peck gave some thought to the selective flotation of sewage solids by a method similar to that used by the authors. Peck has described his tests in which "organic material present in the waste liquors is first coagulated into particles having selective attraction for gas bubbles, separating by a flotation operation which may be of substantially the same nature as is practiced in the mineral flotation art."

As far as is known, no data on the tests performed by Peck have been published. The data presented by the authors substantiate the claims of Peck. This work comes at an opportune time because of the current widespread interest in flotation methods, chiefly for grease removal.

At the Easterly Plant in the City of Cleveland, Charles Hawley developed a flotation process utilizing waste lubricating oil as the flotation reagent. Oil was added to the sewage and the mixture aerated. Many of the suspended solids floated with the oil and could be skimmed off quite readily. The skimmings were then disposed of by burning. In contrast to the fair removal of B.O.D. attained by Hansen and Gotaas, the oil flotation process did not remove much B.O.D., although suspended solids removals were high.

Regardless of any previous concept of the method, the matter of paramount importance to the sanitary engineer is the practicality of applying this method to the economical treatment of sewage and trade wastes. First and foremost is the matter of cost. Dosages of 60 to 80 p.p.m. of coagulant, as recommended by the authors, are common with several of the coagulants normally used in sewage, such as the salts of aluminum and iron. However, the cost of flotation reagents such as DP 243, is between 40 and 50 cents per pound, as compared with a range of from 1 to 3 cents per pound for sewage coagulants. Although the results obtained by the authors are somewhat better than those ordinarily obtained in chemical precipitation plants, the expenditure of from \$200 to \$300 per million gallons of sewage treated is not warranted in any case.

On the other hand, in the recovery of gold from low grade ore worth from \$5 to \$10 per ton, the mill operators can afford the use of this expensive flotation reagent. Using a dosage of 0.5 pound per ton of ore, it would only cost 20 cents for reagent to recover the fraction of an ounce of gold in each ton of ore. In the case of sewage, an expensive selective flotation reagent of this type is not called for. It is to be hoped that this experimental work may be carried on to lead to an efficient and inexpensive reagent to accomplish the purposes of sewage flotation.

The authors point to the efficiency of bacterial removal through the use of this reagent. In the first place, chlorine at 1/10 the cost will accomplish the same results at far lower dosages. In the second place, too many people are prone to judge the efficiency of a sewage treatment process by the percentage of bacterial removal. It must be emphasized that the main purpose of a sewage treatment plant is to reduce the content of putrescible organic matter in the sewage enough to permit the river to carry on its work of self-purification without reducing the dissolved oxygen content below a desired minimum. Sterilization of sewage may only serve to retard the subsequent oxidation process in the river. Where water supplies, bathing, recreation facilities, or nuisances are involved, where conditions call for the disinfection of the sewage plant effluent, the situations are being handled in a satisfactory manner by post-chlorination.

It is the purpose of a discusser to contribute constructive information based on the principles of the original paper. This discusser would like to refer to the process of flotation known as the Adka or Karlstrom Process, which has met with considerable success in the paper industry for the past ten years. Flotation is accomplished by applying a vacuum over a liquid previously saturated with air in a rapid aerator. Experimental results obtained by this discusser are too lengthy to present at this time but indications are that for the cost of electric power for an aerator and a vacuum pump, efficient removals of suspended solids and grease may be obtained. Flotation of the sewage particles is brought about by the release of minute bubbles of air as the pressure of the atmosphere above the sewage is lowered by means of passing the sewage through a vacuum tank. The flotation reagents are provided by the grease and other similar substances in the sewage, thus saving the cost of additional reagents.

The possibilities of flotation of sewage, whether by the addition of chemicals or other means, holds forth promise for future developments in the field of sanitary engineering. As we borrow processes or mechanisms from other industries, they in turn will borrow from us as our development in the separation of liquids and solids progresses through research of the type presented by the authors.

EFFECT OF THE ADDITION OF SODIUM NITRATE TO SEWAGE ON HYDROGEN SULFIDE PRODUCTION AND B.O.D. REDUCTION *

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Nitrates are similar to sulfates in so far as they both can be reduced under anaerobic conditions to supply oxygen for bacterial oxidations. One important difference between these two oxygen-rich compounds is to be noted. Whereas the end product of sulfate reduction is an odorous compound, nitrate reduction results in inoffensive products: nitrates, ammonia and nitrogen gas. What happens when both sulfates and nitrates are present together under anaerobic conditions? Are they reduced simultaneously, or does the reduction of one precede and prevent the reduction of the other? The practical aspects of this question are whether, in the presence of nitrates, the reduction of sulfates and the consequent production of hydrogen sulfide can be prevented, and how much nitrate is required to bring about this desirable result.

There are several sources of information available on the use of nitrate for the prevention of hydrogen sulfide production. An interesting use of sodium nitrate in Coney Island Creek to alleviate the pressing problem of hydrogen sulfide production is reported by Carpenter (1). Chlorinated lime was strewn over the surface of the water to neutralize as much of the hydrogen sulfide as possible and then sodium nitrate was added to prevent the further development of the gas. The hydrogen sulfide content of the water was reduced by this treatment. Even the mud banks seemed to be deodorized. Fales (2) reported the use of sodium nitrate in conjunction with the discharge of treated paper mill and tannery effluents into a stream at extremely low flow during the warm weather. The treatment was effective in preventing offensive odors. A report by Sanborn (3) deals with the use of sodium nitrate for retarding the offensive odors produced from cannery wastes in lagoons. The source of odors in this case was from the reduction of organic compounds and the nitrates were applied as a source of oxygen to satisfy a part of the oxygen demand of the organic matter and thus to prevent anaerobic decomposition. From laboratory tests it was concluded that the addition of sodium nitrate to furnish enough oxygen to satisfy 50 per cent of the five-day B.O.D. gave complete protection against odors. Reduction of the nitrate dosage to the 40 per cent level gave stale or musty odors. Lower dosages of nitrate gave increasing odors.

In addition to these various sources of information it is known that oxidized effluents containing nitrates are stable and do not produce

* Journal Series Paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Water and Sewage Research.

odors. Furthermore, the discarded nitrate method for the determination of the oxygen demand of sewage was based on the principle of the reduction of nitrate and the utilization of the oxygen liberated for the oxidation of putrescible organic matter. It would seem, from the foregoing considerations, that of the various sources of oxygen for the oxidation of organic matter, namely oxygen, nitrates and sulfates, the order of utilization is as given. No nitrate reduction takes place until all the dissolved oxygen disappears and sulfates are reduced after the nitrates. Methylene blue is not reduced until all the nitrates disappear.

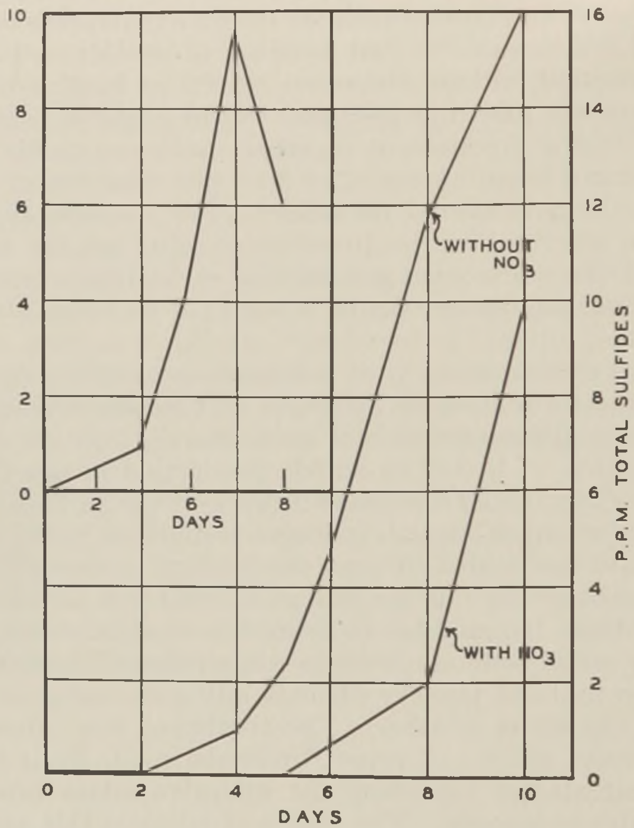

FIG. 1.—The effect of the addition of sodium nitrate on sulfide production from sewage.

It was considered, therefore, of interest to determine the effect of the addition of sodium nitrate to sewage on the retardation of sulfide production under anaerobic conditions. It would be expected that the addition of nitrate under these conditions would also result in B.O.D. reduction. The extent of this reduction was also investigated.

METHODS

Municipal domestic sewage was divided into several portions. Various quantities of sodium nitrate were added, distributed into tightly stoppered bottles and incubated at 20° C. At intervals total sulfides were determined by aspiration of the acidified sample with carbon dioxide gas and trapping the liberated hydrogen sulfide in neutral zinc acetate solution.

Results

Odor Control.—A comparison of the effect of the addition of 120 p.p.m. sodium nitrate to sewage is given in Fig. 1. When no nitrate was added, hydrogen sulfide production started on the fourth day and increased regularly to 16 p.p.m. on the tenth day. There was no sulfide for the first five days when nitrate was added. Thereafter, it increased slowly up to eight days and more rapidly to a value of 10 p.p.m. in 10 days. The figure in the inset shows the difference in sulfide content of the sewage without and with nitrate addition. The

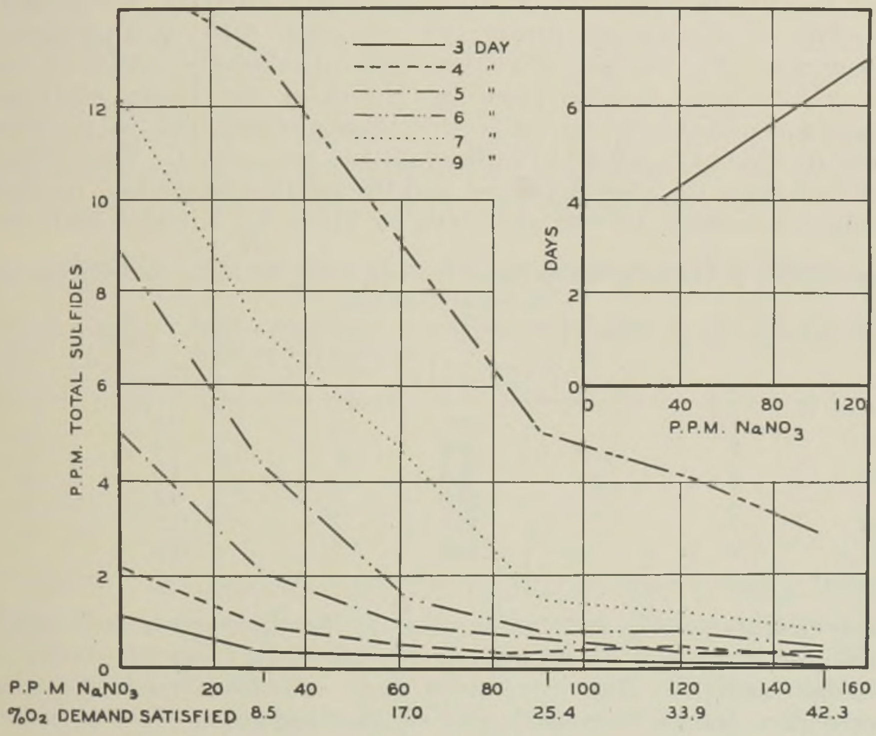

Fig. 2.—The relationship between the quantities of sodium nitrate added and sulfide production.

differences became increasingly greater up to 8 days incubation. Thereafter, the rate of sulfide production with the addition of nitrate was higher than without the addition and the difference decreased. It is of interest to note that the nitrate added had completely disappeared at the end of 24 hours yet its residual effect was felt for a long time thereafter.

In Fig. 2 are presented the results of a more detailed study of the effect of various amounts of sodium nitrate on sulfide production. The addition of sodium nitrate varied from 0 to 150 p.p.m. On the basis of available oxygen in the nitrate the additions represented 0, 8.5, 17, 25.4, 33.9 and 42.3 per cent of the 5-day B.O.D. of the sewage. It will be seen that sodium nitrate had a definite retarding effect on sulfide production, the effect being greater with greater concentration. In fact there is a direct relationship between the concentration of nitrate added and the retardation as measured by the time required to produce 1 p.p.m. of sulfide. This is shown graphically in the inset of Fig. 2.

The results of these experiments indicate that nitrates are effective in preventing sulfate reduction. The preferential reduction might, however, be due to the fact that nitrate-reducing organisms in sewage are present in greater numbers than the sulfate-reducing organisms, and that in sewers where a sulfate-reducing flora is established the effect of nitrates might not be so pronounced. In order to determine the effect of this factor, sewage was enriched with sulfate-reducing organisms by the addition of sludge from a previously septicized sewage. Centrifuged residue from two liters of previously septicized sewage was added to 8 liters of fresh sewage, divided into two portions, to one of which 120 p.p.m. of sodium nitrate was added. The sulfates produced from the seeded control and the portion which had received in addition sodium nitrate are given in Table I. Nitrates had completely disappeared in twenty-four hours. Seeding accelerated sulfide production in comparison with the results obtained from the previously unseeded sewages. But even under these conditions the addition of nitrate gave definite retardation of sulfide production for a period of three days.

TABLE I.—*Effect of Addition of Sodium Nitrate to Sewage Seeded with Sulfate Reducing Organisms on Sulfide Production*

Days	Total Sulfides, Parts per Million	
	Without Nitrate	With Nitrate
1	0.8	0.9
2	3.0	0.4
3	7.5	1.0
5	13.0	6.2
7	13.7	11.5
9	14.0	12.6

B.O.D. Reduction.—Different quantities of sodium nitrate were added to the sewage, which was kept under quiescent conditions in open vessels and B.O.D. determined. The results are given in Table II. The B.O.D. in the control decreased from 117 to 103 p.p.m. The addition of sodium nitrate accelerated the reduction. With higher quantities of sodium nitrate, greater reductions were obtained. The reduction of nitrate was not complete in one day with the largest dose of sodium nitrate. The B.O.D. removed per unit of oxygen in the sodium nitrate added varied by .57, .85 and .58 with the 25, 50 and 100 p.p.m. doses respectively.

Table II.—*Effect of Sodium Nitrate Additions to Sewage on B.O.D. Reduction*

$NaNO_3$ Added P.p.m.	Initial P.p.m.	After 1 Day P.p.m.	Decrease Over Initial P.p.m.	Decrease Due to $NaNO_3$ P.p.m.	O_2 Supplied by $NaNO_3$ P.p.m.	P.p.m. B.O.D. Reduced / P.p.m. O_2 Supplied by $NaNO_3$
0	117	103	14	—	0	—
25	117	95	22	8	14.1	.57
50	117	79	38	24	28.2	.85
100	117	70	47	33	56.5	.58

The experiment was repeated in closed bottles in order to prevent atmospheric reaeration. The results are given in Table III. The nitrates disappeared completely in one day except with the 200 p.p.m. addition of sodium nitrate. The B.O.D. in the control decreased by 20 p.p.m. in one day. The decrease in B.O.D. was greater with sodium nitrate additions, the difference increasing with the higher concentrations. The ratio of B.O.D. reduced to O_2 supplied, due to the addition of sodium nitrate, increased from .42 with 25 p.p.m. addition to .65 with 100 p.p.m. addition. With 200 p.p.m. addition this ratio was 0.4, probably due to the fact that nitrates were not completely reduced. The ratios were generally lower than in the previous experiment.

Table III.—*Effect of Sodium Nitrate Additions to Sewage on B.O.D. Reductions*

$NaNO_3$ Added P.p.m.	Initial P.p.m.	After 1 Day P.p.m.	Decrease Over Initial P.p.m.	Decrease Due to $NaNO_3$ P.p.m.	O_2 Supplied by $NaNO_3$ P.p.m.	P.p.m. B.O.D. Reduced / P.p.m. O_2 Supplied by $NaNO_3$
0	143	123	20	—	0	0
25	143	117	26	6	14.1	.42
50	143	107	36	16	28.2	.56
100	143	86	57	37	56.5	.65
200	143	78	65	45	113.0	.40

There is an available source of nitrate nitrogen in most trickling filter effluents. The return of such effluents to sewage with adequate detention might result in higher B.O.D. removals due to (1) the nitrates in the effluent and (2) the seeding with oxidizing organisms. In order to determine the value of returning trickling filter effluents on the oxidation of sewage, and the relative role played by the nitrates and the organisms in the effluent, two experiments were run. Sterilized and non-sterilized trickling filter effluents from standard filters were obtained and mixed with sewage in equal volumes. The control consisted of sewage diluted with an equal volume of water. Comparison was also made with diluted sewage to which sodium nitrate was added in amounts equivalent to the quantity of nitrate in the trickling filter effluent. The results are given in Tables IV and V.

In the first experiment the sewage mixed with trickling filter effluent had a lower initial B.O.D. than the control, in the second experiment the reverse was true. But in both tests the B.O.D. reduction with the

TABLE IV.—*Effect of Nitrate in Trickling Filter Effluent on B.O.D. Reduction of Sewage*

Treatment	NO_3–N P.p.m.	5 Day B.O.D.		
		Initial P.p.m.	1 Day P.p.m.	Decrease P.p.m.
Sewage	0	102	76	26
Sewage + $NaNO_3$	6	102	69	33
Sewage + trickling filter effl.	6	66	34	32
Sewage + trickling filter effl. sterilized	6	66	33	33

TABLE V.—*Effect of Nitrate in Trickling Filter Effluent on B.O.D. Reduction of Sewage*

Treatment	NO_3–N P.p.m.	5 Day B.O.D.		
		Initial P.p.m.	1 Day P.p.m.	Decrease P.p.m.
Sewage	0	117	103	14
Sewage + $NaNO_3$	8.0	117	79	38
Sewage + trickling filter effl.	10.0	148	107	39
Sewage + trickling filter effl. sterilized	10.0	153	109	44

trickling filter effluent was equal to sewage to which an equivalent quantity of sodium nitrate was added. Furthermore, no greater reductions were obtained with the non-sterile effluent than with the sterile effluent. It appears that the beneficial value of trickling filter effluent resides in its nitrate content and not in the seeding with oxidizing organisms.

Discussion

The retarding influence of sodium nitrate on sulfide production from sewage which has been shown in this study cannot be attributed to any direct inhibitive or toxic action of the nitrate. The proper explanation should take into consideration the preferential reduction of nitrates, rather than sulfates, under anaerobic conditions. The reduction of the added nitrate was complete during the first twenty-four hours and yet the residual effect on sulfide production was exerted for a longer period. Therefore, another indirect factor plays a role, namely the oxidation of putrescible organic matter by the oxygen liberated from the reduction of nitrates. As the putrescible organic matter becomes oxidized the need for the reduction of sulfates is diminished. The direct relationship between the sodium nitrate dosage and retardation in sulfide production is to be attributed to the increased oxidation of organic matter by the oxygen in the nitrate.

An additional value from the addition of sodium nitrate is the reduction of B.O.D. Sodium nitrate, both from the standpoint of odor control and B.O.D. reduction, would be uneconomical except under unusual circumstances and could not compete with chlorine used for the same purposes. However, the nitrates contained in the trickling filter effluent should be of value in this respect. It is also of interest to note that the value derived from the contact of sewage with filter effluent does not arise from the seeding with oxidizing organisms but from the nitrates. Therefore, effluents containing little or no nitrates should be of indifferent effect, except in so far that they may contain appreciable quantities of dissolved oxygen. Recycling of high rate filter effluents into the sedimentation tanks have been claimed to result in added advantage in removing B.O.D. If such is the case then other factors such as dissolved oxygen or dilution might play a role rather than the nitrates or the seeding.

Summary

Experiments with additions of sodium nitrate to sewage have shown that the sodium nitrate reduces and delays sulfide production from sewage. The effects were proportional to the quantity of nitrate used. Nitrate further has the effect of reducing the B.O.D. by a value equal to 0.5 to 0.8 for each unit of oxygen in the sodium nitrate added. The mixing of sewage with trickling filter effluent results in removal of B.O.D. equivalent to the nitrate content of the effluent. The organisms in the effluent seem to play only a minor role in the higher removals of B.O.D.

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THE OPERATOR'S CORNER

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

PLANT MAINTENANCE IN WAR TIME

This entire issue of the Corner is devoted to the four outstanding papers and discussions which comprised the Symposium on Sewage Works Maintenance in War Time in the program of the recent Federation Conference at Cleveland. Those in attendance at this session will agree that it was one of the real high-lights of the meeting.

In ordinary times, proper maintenance of plant structures, equipment, buildings and grounds is a main function of operation personnel but today, in the midst of total war, maintenance assumes a significance far beyond its peace time place. Inadequate and careless attention to maintenance now means that all or portions of the sewage works may be thrown out of service for indefinite periods; that avoidable health hazards to military and civilian population may be created; that war industry may be hampered; that critical materials may be wasted. In short, faulty maintenance today is *sabotage!*

Practice of the following principles of sound maintenance procedures is a real contribution to the successful prosecution of the war:

Vigilance
Inspection
Cleanliness
Thoroughness
Oil
Repair
Ingenuity
Orderliness
Ultrafrugality
Substitution

SEWAGE PLANT MAINTENANCE IN WAR TIME: MECHANICAL UNITS

By John W. Johnson

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In this World War II, our "Four Horsemen of the Apocalypse" are Priority, Rationing, Substitution, and Labor turnover. These plagues

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have hunted the country-at-large and have hounded us in particular. Failure of a machine is disheartening even in normal times, but now when replacements cannot be obtained, even with a preference priority, the possibility of being flooded out or overloaded, provides a gloomy outlook as the "stuff" keeps pouring in—rationing notwithstanding. The office work, filling in forms, signing this affidavit and that, is relentless; repair work falls behind and the men are crying for raises. One begins to consider the Army a very attractive proposition.

But, it is reported, the Army also has trouble. Uncle Sam's armed forces have billions to spend in this war, yet, like many a man-on-the street, these departments simply cannot obtain a lot of common materials for love nor money; even for use in weapons.

By this unparalleled drain on our natural resources due to war requirements, we are challenged to conserve and substitute; we must resort to our American ingenuity; do with what we have and be ever on the alert for new uses of old materials. We must coddle, if necessary, our present installations of machinery and equipment, and call on the vast store of knowledge acquired throughout the years to combat this problem.

We may, for example, look into labor-employer relationship for help. Much good has been derived by sharing the plant problems with employees. Several of the defense industries have reported the use of suggestion boxes placed throughout the plant as having solved many operating and production problems. Often "green" personnel will come through with an idea which will save time, money and vital materials.

Revision of equipment presents an opportunity to meet the problems. At Tulsa, Okla. (1), the Oklahoma Pipe Line Company had a 3,500 r.p.m. centrifugal pump and 150 h.p., 1,700 r.p.m. electric motor to drive it. It was discovered that the speed-up gear they had planned to use was not available, due to material shortage. A belting engineer was called and he developed a simple but effective V-belt drive design. The sheave used was made small in diameter in order to avoid excessive belt speed at the high r.p.m. These small sheave diameters meant the use of smaller belt sections, and this in turn meant a number of belts in order to transmit the horsepower load. The final completed belt arrangement occupied a limited space, and did the desired job.

Mr. John Horn, of the General Electric Company (2), reports that his company's problem is to conserve many of the vitally needed war materials now on hand, such as aluminum, tin, copper, rubber, mica, tungsten, formaldehyde, phenol base resin, plastic, shellac, toluene, and tung oil. They are accomplishing this, in some instances, by direct substitution, or by reduction in quantity of materials used. Changes in design are also made so that alternates can be used.

Methods, which this company has utilized, include the use of steel in place of structural aluminum, with a saving of over seven and one-half million pounds of the latter in one year. In another instance, changing the thickness of mica insulations from 0.03 to 0.02 in. has resulted in a saving of thirty-eight hundred pounds of mica per year. As you know, the best mica is imported from the Island of Madagascar, and is split by hand. The General Electric Company is using the imported mica for the more vital insulations, while domestic, machine split mica is used for the remainder. Mr. Horn further reports that some of the transformers are now being designed with silver, a precious metal, replacing copper, a base metal. Ironically, silver is also being used in solders to replace tin.

At Buffalo it has always been our endeavor to keep ahead with preventive maintenance, but there are some things, peculiar to each plant, that will continue to tax the imagination. Emphasis is now given, therefore, to the analyses of satisfactory solutions.

We have had a continuous problem of abrasive wear in the sludge incinerating equipment. The steel blades and linings of induced draft fans had to be removed at the end of a sixty-day operation period. Steel plate linings in the sludge and ash cyclones, subjected to the high velocity and temperature of sludge, wore out quickly. The lines feeding the sludge to the incinerator developed leaks at all bends. The lines conveying the hot ash, after combustion, similarly failed at the turns. As the supply of metals decreased, due to stock depletion, or to priorities, new methods and materials were employed.

By changing the location of the induced draft fans to the clean air side of the cyclones, the wear due to abrasion was eliminated and the operating life of these fans increased one thousand fold. In the matter of relining the interiors of the cyclones, several materials have proved to be as good as, and in some instances, better than the original metals used. These cyclones consist of a cylinder 9 ft. in diameter and 5 ft. high, topping an inverted cone 10 ft. high.

About two years ago, gunite linings 2 in. thick were installed in two of the cyclones. This lining is still in service in the sludge cyclone, but in the ash cyclone, when operations were first begun, it failed immediately because of the following reasons:

1. There was a slight delay between the time the first coat of gunite was completed and the second coat applied, due to an intervening lunch hour.
2. This particular unit was adjacent to a furnace which was in operation at the time, and the radiated heat may have caused the concrete to dry too rapidly.
3. The gunite may not have been fully dried after curing, and as the temperature was raised when operations started, steaming occurred, causing the concrete to fail.

There is no doubt that cement lining (gunite, pre-cast or poured with forms) could be used for this service, if good control is exercised in the selection of the aggregate, placing and curing of the concrete. At Chicago's Calumet plant excellent results have been obtained with gunite cyclone linings, using a trap rock aggregate.

Because of the uneven wear of the lining face, it has always been necessary to install patch work before complete renewals were made. Repairs on the gunite lining made with new gunite, or hand-trowelled mortar, did not stay in place. Our next attempt was made with a 4″ × 4″ × 8″ paving brick, laid up in common mortar, which made a satisfactory repair other than the renewal of joints. These paving bricks were part of the rubble which we had been collecting for some time to build retaining walls along the ash dump areas.

Two additional cyclones were then completely lined with smaller 4″ × 2″ × 8″ used paving brick, set in a mortar of a material called "Firefrax" cement, manufactured by the Carborundum Company. When the units were first heated, about two dozen of the pieces exploded due to the presence of unburned lime within the brick. These locations were repaired with heat tested brick and the installation has given good service for over one year.

This experience directed investigations along the line of ceramic materials. Because of satisfactory service with cyclones lined with paving brick, further studies were made on the subject. Samples of various materials were placed in a laboratory muffle, where a temperature ranging from 700° F. to 930° F. was maintained for a period of thirty-six hours, or more. The abrasion resistance was determined by measuring the penetration into the material in a five second period of rapidly rotating thin carborundum disc ($\frac{7}{8}'' \times \frac{1}{64}''$ at 23,000 r.p.m.). The following table gives the results of these tests.

Source	Penetration	Heat Resistance
Duro fire brick	0.55 mm.	40 hr. at 800° F.—O.K.
Packing house floor tile	0.40 mm.	40 hr. at 800° F.—O.K.
Trap rock and lumnite cement	1.39 mm.	800–900° F.—O.K.
Haydite and lumnite cement	3.72 mm.	800–900° F.—O.K.
Mayari-R low carbon, chromium steel	0.35 mm.	O.K.
Cold rolled steel	0.30 mm.	O.K.
4″ × 4″ × 8″ paving brick	0.56 mm.	Repeated heating up to 800° F.—O.K.
4″ × 8″ × 2″ paving brick	0.80 mm.	Cracked, exploded before reaching 350° F.
4″ × 8″ × 2″ paving brick (previously used and cracked in cyclone)		Frequent cracking before reaching 350° F.

These tests indicated that some of the ceramics would withstand as much penetration as the steel plates, which were used in the original lining. Since the packing floor tile withstood the peneration test with a value comparable to abrasion resistance steel and several pieces have given good series in a test installation, it was selected for the lining of the third set of cyclones. A quantity of these tile have been received in standard and special shapes to conform to the interior contour of the cyclones. Setting of these tile as linings will be completed shortly (Fig. 1).

The sludge feed lines supplying dried sludge to the incinerators were equipped with shaped wearbacks in the form of a steel plate box, filled with concrete at the point of excessive wear (3). Since that time, it has been found that a quarter-inch coating of the same "Firefrax" cement applied to the wearing surface of the concrete of the wearback before initial set, will give a longer life and eliminate plugging, which had occurred when the softer particles of the regular concrete aggregate wore out unevenly.

The wearbacks on the pneumatic ash removal lines are made of a tough and brittle cast iron. Previously, when wear caused holes to develop, the pieces had to be scrapped, but now, by electric welding with cast iron rods, it is possible to build up the wearing face several times, at a fraction of the replacement cost.

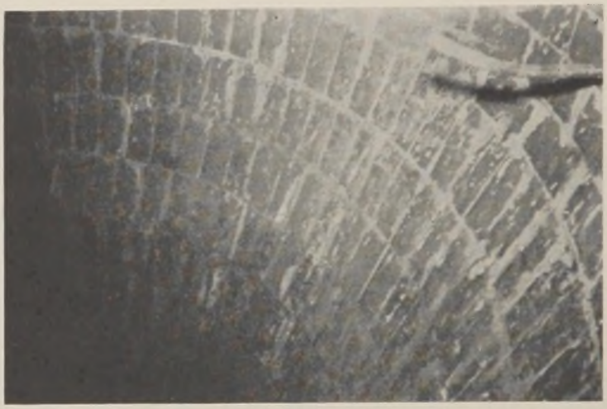

Fig. 1.—Cyclone lining of floor tile

This wear from abrasion naturally affected the flash dryer cagemill assembly of the incinerators. After a service period, it was found that the entire area about one foot in from the outer circumference of the 54 in. diameter, 1 in. thick steel back plate contained a series of depressions scooped out in front of the perpendicular members, and ridges in the rear where the sludge had been deflected. To renew the crossbars for the pulverizing of sludge, it was impossible to keep the assembly in alignment, as the bars set to the true front surface would naturally fail to touch the face of the worn back plate. The problem of machining so large a diameter might have defeated our salvage efforts, but we were fortunate in having this work done by a local ship building company. A half-inch cut in thickness was made, from the outside circumference 12 in. in; this machined area was then fitted with segmented arcs cut from half-inch scrap steel plate and spot welded (Figs. 1A and 2) to make up the original surface. Assembly work then proceeded without difficulty.

In co-operation with the Chain Belt Company, we have at present under test operation sixteen various alloys made into teeth in a screenings grinder. This company found it impossible to obtain the material which was originally used in the high speed heavy duty shredding machine. The results of this test will, no doubt, provide a workable substitute. The recoil devices on the wiper bar for cleaning screenings from the mechanical screen rakes were subjected to heavy pounding and frequently failed. By employment of a counter-balance, this breakage has been eliminated.

The metal evaporators and containers, a part of the chlorine installation, were attacked by the corrosive action of vapor of the water bath. This corrosion was so deep that there was danger of failure of the containers and leakage of the evaporators. Protection has now been afforded by a three-inch layer of light oil floating on the surface of the heating water. This medium has sealed in the steam vapors to the extent that corrosion is eliminated and replacement of evaporators will not be necessary.

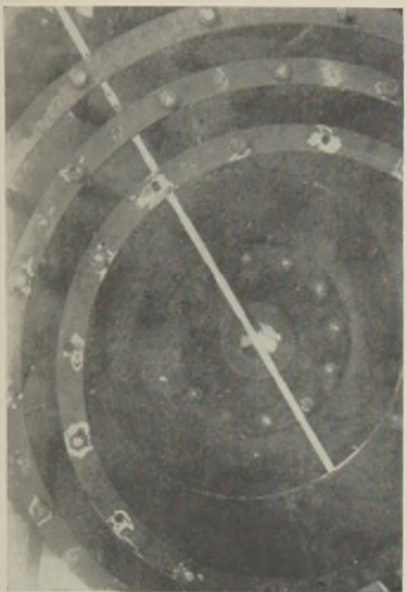

Fig. 1A.—Face of cagemill with renewed area on back plate.

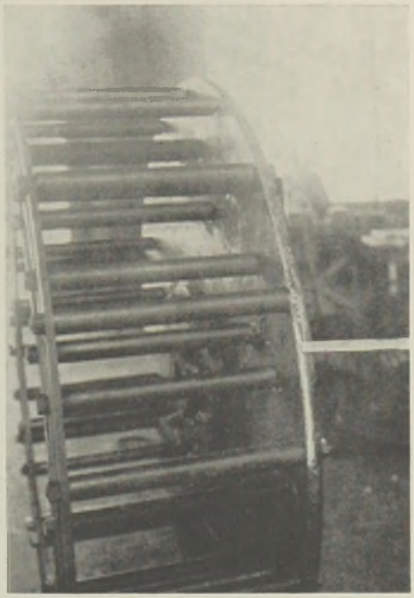

Fig. 2.—End view of cagemill showing joint between original and new plates.

Frequent high discharge pressures in the raw sludge line caused a high mortality of sludge pumps, constructed of cast iron. Pistons, housings and eccentrics broke so often that the maintenance cost exceeded all reason. An experimental plunger pump was constructed entirely of steel. This gave excellent service during a year's test without a single breakdown. To rebuild the remaining seven pumps, however, would require so much steel that it was useless to attempt the purchase. Because good results had been obtained with the use of "Meehanite" metal, which has a high tensile strength and is described as a connecting link between cast iron and steel, a pump was designed, patterns made, and a complete pump cast with "Meehanite." Early tests have indicated that this pump will give service equal to that of a steel pump (Figs. 3, 4, and 5).

Because the flow studies on the sedimentation tanks indicated better settling results with a shallower center baffle, the original 8 ft.

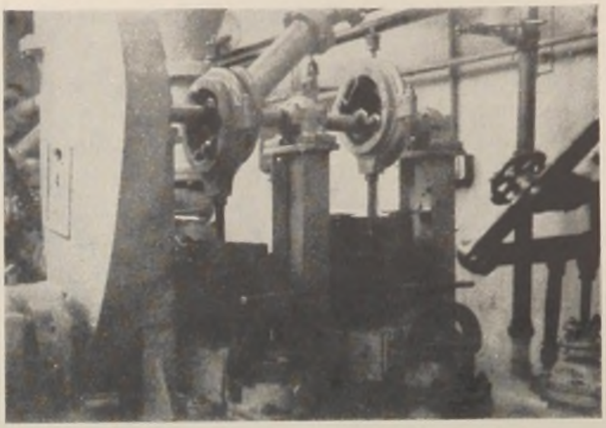

FIG. 3.—Original cast iron sludge pump.

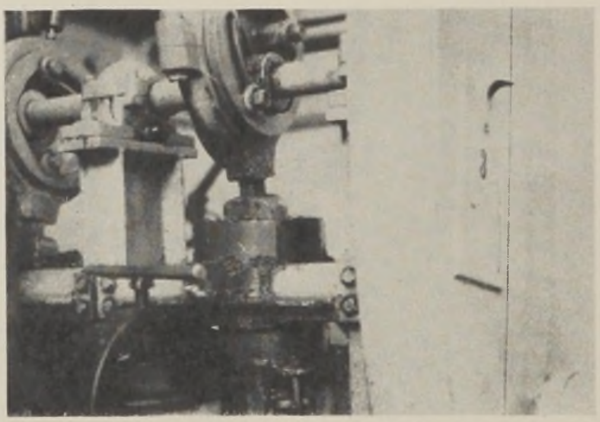

FIG. 4.—Steel sludge pump.

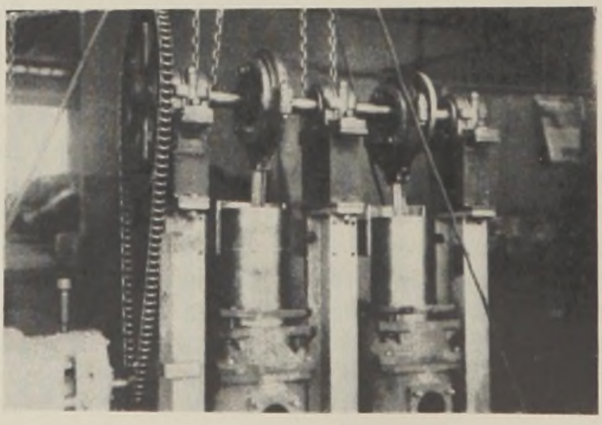

FIG. 5.—"Meehanite" sludge pump.

inlet baffle of 1/4 in. steel plate on one tank was replaced by two spaced strips of 6 in. wood sheeting (Figs. 6 and 7). The steel plate obtained from this tank has provided us with material for repairs in locations where only steel could be used. The wooden baffle can easily be replaced, but is expected to give satisfactory service after treatment with a bitumastic paint.

FIG. 6.—Installation of center wood baffle.

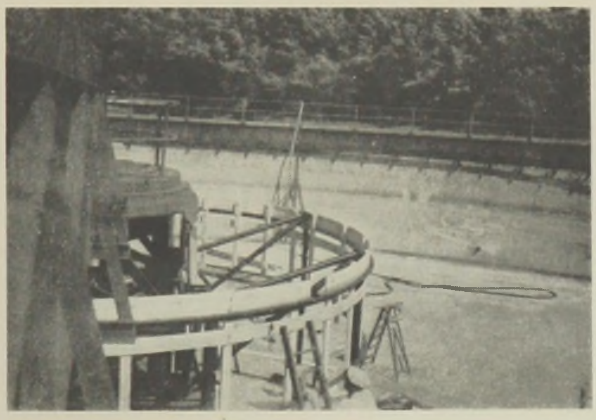

FIG. 7.—Close-up of center baffle.

From the Chicago Sanitary District was obtained the idea of substituting a heavy sash cord in lieu of the brass bars, which were inserted on the face of the vacuum filter to separate the filtering segments before the holding wire was installed over the cloth. This has resulted in a two-fold benefit, first, shorter installation time, and secondly, use has been made of the salvaged brass bars.

Speaking of filters, the life of Canton flannel filter cloth at the Buffalo plant previously averaged about 200 hours. Just before cloth failure, operations were often unsatisfactory because blinding or ripping along the seams allowed solids to pass through and plug the filtrate pumps beyond. To extend the operating hours to a maximum, experiments were inaugurated using acid of varying strengths to dissolve the calcium carbonate encrusted on the cloth fibers. At the present time, all cloths are subjected to an acid bath approximately every hundred hours, with a solution of one part 20° Baumé muriatic acid and one part water. The cost of this treatment, when compared to the added life of the cloth (one cloth ran almost 400 hours), is nil. The process is really an economy, as this fabric is vital to the war effort and can be obtained in only limited quantities; likewise, a saving in the steel winding wire has been realized. Mr. K. L. Mick, of Minneapolis (4), also reports success with acid washing of filter cloth.

And what of the lowly wiping cloth that cleans the mechanical units? No one ever thought very much about that. "Help yourself." "Take as much as you want," was the rule. But that is all changed now. The price in Buffalo has increased from $0.10 per pound for near white rags to $0.22 per pound for any color or type, when and if they are available. Each department has now been limited to a monthly ration. Fireproofed covered cans have been placed throughout the plant where all soiled rage are deposited. The cloths are being laundered (average about three times) at a cost of $0.07 per pound. By this procedure, it has been possible to reduce the annual consumption of cloths from six thousand to one thousand pounds.

As you are well aware, many parts of chlorine apparatus are made of very special materials. One such material, which is resistant to the corrosive action of chlorine, is known as "Isolantite." Even before December 7 production of this material was diverted into defense uses. When five injector tips made of "Isolantite" were ordered recently, we were informed there were only five available in the whole country. This particular part acts in the injector throat of the chlorine solution line and is intricate in design, having a parabolic contour running from a globe-like base to a near point, at the top; on the surface of which are fixed three fins (Fig. 8). The first endeavor to duplicate this part was done with babbitt in a plaster mould. The result was serviceable, but had too much weight. An attempt was then made to machine the part from hard rubber stock. This produced a surprisingly good duplicate, which is still giving service, but as additional rubber stock was not available, another substitute was sought. Bars of phenolic base plastic were obtained from a local plant, and were machined to form the part as was the hard rubber. These are also giving satisfactory service.

Bakelite tubing has been used to repair hard rubber cylinders of sludge meter floats. Bakelite and other phenolic base resins, however, are now on a high priority list. Our next venture, no doubt, will be with other organic base plastics which may not withstand all chemical reactions, but should have other uses.

We have a number of motor vehicles; five truck and two passenger cars. While we were fortunate to obtain one new set of tires, after rationing went into effect, we intend to help the general situation by giving tires our first consideration. We have subscribed to all suggestions of the Office of Defense Transportation, as to tire rotation, proper loading, correct pressure, and have reduced operation of the vehicles to a minimum. All motors, rear-ends, hoists, and bodies are checked weekly; lubrication and oil changing records have become of paramount importance, and although we are still able to obtain most parts from dealers' stocks it behooves us to be careful of our present equipment since new production is nil.

Fig. 8.—''Isolantite'' injector tip.

Great Britain, according to the War Production Board, has done a splendid job in maintaining transport service. After three years of war, most of her trucks are still running. While they had a less ample supply of spare parts than we did at the respective war starting dates, they have, despite the heavy losses from air raid destruction, maintained most of their vehicular facilities. This they were able to do by the development of many methods of reclaiming and rebuilding used parts. These technical developments include the over-sizing of piston pins by chromium plating, metal spraying and chromium plating of crank shafts, applying stellite to worn cams, turning down valves to smaller sizes, and reclaiming many other items which before the war were considered ''junk.''

When we asked Edward J. Smith, Superintendent of the Niagara Falls Treatment Plant, what he was doing to avoid priorities and scarcity of materials, he said, ''One of our outstanding jobs is the recutting of drive sprockets after building up the worn spots by electric welding.'' Concrete is now replacing worn out metal bottoms of the grit washers at Niagara Falls, and babbitted bearings have been installed in lieu of ball- or roller-bearings in many instances where the bearing speed is not excessive. Mr. Smith also reports that in the incinerator equipment, the forward baffle arms which have been burned at the center are being salvaged and are being used after new teeth are cut into them in the reverse direction, in place of new back rabbles to retard the sludge on the various hearths.

In the words of Mr. Smith, "One of the big problems of maintaining mechanical units is to educate shoemakers into mechanics." True, personnel has has become a maintenance problem; the tremendous demand on manpower for war work makes it impossible to hold men at the peace time wage levels, paid by municipalities. The higher hourly wage rate, plus the opportunity for overtime work in war industries, has become too attractive to many men with mechanical tendencies.

Since many of the sewage plants commenced operation during the depression, exceptional men were available for employment. This was particularly true at Buffalo, where excellent maintenance and operating departments were organized. However, since the first of this year, there has been a loss of about 25 per cent of the plant employees, and replacements have not been equivalent as to number, age, or experience. "Ed" Smith reports hiring four women in his chlorine department. It may not be long before this reservoir will have to be tapped to produce operators, mechanics, blacksmiths, truck drivers, and so forth, which we shall require. As sewage plants become older, more maintenance work will be required, and this increasing labor turn-over becomes a serious problem.

We might continue to great length about the care of pumps and equipment, about lubrication and servicing electric motors, about general cleanliness and care of equipment, but it isn't necessary to tell sewage plant operators to be good housekeepers. They have always been so, formerly for the plaudits of the taxpayers, and now to conserve and protect our resources, as a jolt to the Axis powers. We Americans have been a wasteful people. The production of goods reached a point where it was possible to meet our needs without too much cost and within our budgets; we were often forced to scrap serviceable units because competition demanded it. Sometimes replacements were easier or cheaper than repairs, and how often the automobile, with many thousands of miles left in it, was traded for a shiny new one—"Keeping up with the Jones," in other words.

To keep our "way of life," we must drastically change our "way of life," and, for the present, that means sacrifice, frugality and industry. Where mechanical units are concerned, I repeat again, take care of what you have. No matter how small it may be, it is most vital in the light of replacement.

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Discussion of Paper by John W. Johnson

CHAIRMAN C. C. LARSON: Thank you, Mr. Johnson. I think you will have to agree with me that Mr. Johnson has covered a good many subjects and has shown remarkable ingenuity in handling various repairs at Buffalo. I was particularly struck with his use of the word maintenance. We usually think of maintenance as taking care of something after it is broken. His use of the words "preventive maintenance" is probably the keynote to maintenance in sewage plants at this stage of the game.

In order to get a little geographical distribution, I am going to ask Mr. Rawn of Los Angeles to make a few remarks. We are very grateful to those gentlemen for traveling so far. I would like to have him tell us something about the west coast. Mr. Rawn of Los Angeles!

MR. A. M. RAWN: I was having something of a postman's holiday and consequently, when I came to Buffalo from Niagara, I availed myself of the opportunity to go out and see Mr. Johnson's plant. I can assure you he shows all the ingenuity that is inherent in the engineering profession.

It is fortunate indeed for the public at large that at least 50 per cent of all engineers and particularly that the civil engineers come from very poor but honest families. Nearly 50 per cent have to work their way entirely through college and of the remainder there are probably not more than 10 or 15 per cent who are able to pay or whose folks are able to pay their way for them. It gives them an ingenuity that is not inherent in many of the other professions, particularly if they come from the farms, as many of us have.

Mr. Johnson has an excellently equipped shop. It is a mechanic's paradise. As far as I can see, he has some excellent mechanics who are doing a fine job of repairing equipment and machinery and doing it with materials which he couldn't buy otherwise.

He had a series of gears or bearings that he was repairing in the shop and I asked him why he didn't buy them on what I understood then was an A–1–C priority. He told me that the A–1–C priority would get gears if anyone had them but nobody had them, and so he had to build them himself.

Our problems on the west coast are compounded a little bit by what you heard this morning from the WPB representative from Washington. He suggested that we buy more things in the middle west and ship them out even at the cost of the extra freight. There aren't a great many things that we can buy any more to repair or replace our mechanical equipment. Consequently, we are doing everything we can to substitute other materials for those which are critical, and at the risk of repeating something which I wrote not long since, I am going to tell you of one thing we did at our plant in Los Angeles County, which saved us an amazing amount of equipment, of strategic material and yielded very excellent results.

We had been having difficulty with electrolysis and corrosion and the flaking up and scaling up of sludge-forming devices that are installed within the various sludge digestion compartments. In addition to that, we have been experimenting for a number of years with the possibility of heating sludge and controlling temperatures by some easier means than installing coils and circulating warm water.

Recently we had occasion to extend the facilities in our plant. We had a number of idle tanks left over from the other plant operated to convey the effluent to the Pacific Ocean. Instead of installing coils in those tanks, which would have been very expensive, we simply covered them over with a timber and asphaltum roof, sealing them down as tightly as we could. The tanks are 12½′ × 12½′ in. sections and 157 feet long, and we were heating the sludge with live steam. In our instance that permitted us to make use of a very inexpensive cover on an already constructed tank without going to the necessity of constructing new tanks, but it opened up a field of possibility which should appeal to anyone who wants to digest sludge under controlled temperature conditions and has not the modern facilities with which to do it.

Our problems on the west coast are not as great as yours are in the east. The population tributary to the plant of the Los Angeles Sanitation District is nearly as great as that served by the Buffalo plant. The flow of sewage is in the ratio of about 50 to 60 gallons per capita as opposed to 213 I believe Mr. Johnson told me or we calculated while I was there, and where he has a battery of pumps for storm flow of sewage and for dry weather flow, I believe six pumps each having a daily capacity of 130,000,000 gallons, we have something which is materially less, obviously. His normal flow is at 130,000,000 gallons, I believe; ours is something like forty or forty-five for the same population.

It is interesting to see the sludge incineration problem that he has. Therefore, again we have the advantage of you on the east coast because we take out of the sludge everything that is saleable and sell the residue to the companies which are adjacent to our agricultural land and raise these unkissed oranges I have been paying forty cents a glass for the juice of here in the hotel. (Laughter.) We sell the residue to the orange growers and it does an excellent job and they are very happy to pay for it, and I noticed the other day that we are undergoing a little competition because here from Milwaukee going to the valley of orange groves was a truckload of paper sacks bearing the magic name "Milorganite." You will recognize that, coming from Milwaukee and shipped to Los Angeles and environs for agricultural purposes.

There isn't a great deal more I can add. I think the subject is very comprehensively covered. We certainly have to be saving and frugal. We have to substitute a lot of things for things we have been accustomed to. We are going to get along without many of the implements we have had in the past, and I think Mr. Dorr's statement this noon that the honey wagon may pass our doors again isn't as far fetched as it might be, that is, if we can get enough strategic materials to keep the honey wagon passing. (Applause.)

Chairman Larson: Thank you, Mr. Rawn. It is indeed gratifying to hear a man from Los Angeles and California not making any apologies for the unusual weather they are having out there.

Now gentlemen, perhaps you would like to ask some questions. These are to me intensely interesting samples that Mr. Johnson has brought. Would any of you like to question him about them? I am sure you are all interested. You would hardly believe a paving brick would be worn down four-fifths of the depth. What was the abrasive agent, just dried gum?

Mr. Johnson: Dried lime.

Mr. W. A. Allen (Pasadena): I would like to ask Mr. Johnson if he ever considered lining the flues and cyclones with carborundum brick.

Mr. Johnson: No, we haven't lined the flues with carborundum brick. We never thought of that, but we have used this "Firefrax" cement which I spoke of to line several of our drying towers where, subject to heat and some abrasion, this material served very well. Bricks could have been used there, but what we did was to erect a wooden form suspended in the drying tower and poured the "Firefrax" in place and I imagine it has the same constituent as the carborundum. It is made by the Carborundum people.

Mr. Allen: Speaking of your screening flight gears, the material you have mentioned, "Meehanite," we have found most suitable for grinding fertilizer, and it is very economical.

I would like to also ask if you tried woolen blankets on your filters. We have had very good luck with these. We have gotten as long as eight to nine months continuous service out of a woolen blanket and find it necessary to give those an acid bath of muriatic acid, a solution of about 1 to 35 every 30 or 45 days.

Mr. Johnson: We have tried several different cloths. We have tried ordinary duck cloth but that lacked the testing, the fuzzy material on the face of the Canton flannel keeps out the finer particles of silt and binds it up after about 50 hours. We tried wool cloth but since our chemical dosage of lime is so high, they didn't stand up. We also tried burlap but burlap was a little too coarse and we had plugging of our filtrate pumps.

Mr. Allen: If I had remembered you used lime I wouldn't have asked that question. We tried that ourselves and I know exactly what you got into.

Mr. W. D. McIlvaine, Jr. (St. Paul): I was wondering about the babbitt you mentioned. We have an application that we are wondering about where we use ten wind babbitt on the bearings for shafts of hot gas fans and I was wondering if you or anybody else has had experience using the new substitute babbitts which I understand cannot contain over 12 per cent tin.

Mr. Johnson: We were fortunate in having a large amount of babbitt on hand. I know it is impossible to obtain any more. However, I might steal from my colleague here at the "Information Please," and say that maybe we will be using silver in babbitt. The General Electric Company have substituted silver in place of tin to make up babbitt.

For the reason that we have pre-war babbitt on hand we haven't investigated any of the substitutes.

Mr. McIlvaine: We have orders from some of the manufacturers of new babbitt. They thought it would be satisfactory but we would like to have information from somebody who has tried it. Just last week we were able to buy genuine babbitt out in the Twin Cities. That was a retail outlet and it was entirely legal according to the WPB, but that is just a chance of finding a local supplier that had something he would let loose of.

Mr. Allen: Talking about frugality, on the west coast we save our old bearings and when we run short of babbitt we melt them up and we are not so fussy about the exact content of anything, just so it works.

Mr. L. W. Van Kleeck (Hartford, Conn.): There is one substitute that I might mention and that is the use of wood for bar screens and for tide gates. Some of our plants in Connecticut have been using the wooden tide gates for years and finding them as satisfactory as the metal gates. Recently one operator who had to replace an existing metal bar screen at the pumping station couldn't get the metal for a new bar screen and he made one of wood which has been very satisfactory. In fact, I understand the power companies have been using these wooden racks for years and prefer them to metal.

Mr. Johnson: I made a statement here in the paper that in our sedimentation tanks they came equipped to us with an eight-foot baffle made of steel, quarter inch plate. It was found in our sedimentation tank studies a shallow baffle would give us better removals and for the past several years we have been experimenting by reducing these baffles. The last one that we undertook, we removed the entire baffle and in its place installed two pieces of six inch sheeting, suitably treated with mastic paint. Incidentally, for this plate which we salvaged we have found other uses where steel only could be used. Our last order, however, for some six inch sheeting we had to wait six weeks on account of priorities, so maybe the wood is not so satisfactory after all. Plywood and lumber of all descriptions has gone on a rigid priority in our section.

Mr. W. W. Mathews (Gary, Ind.): We have gone further than these gentlemen. We are using bearings made out of wood. We were denied some fiber bearings for the agitators in the digesters and wanted to get a digester back into operation, so we turned a couple of halves out of a maple wood block and it has been running now for three months. I will not guarantee how long they will run but they are in operation. We are going to run them until they fail. We can tell by the whip developing in the shaft. That was a case of having to substitute under emergency conditions and it has worked so far.

Mr. Niles: Mr. Chairman, I thought perhaps those here might be interested in the experience that we had in Toledo with substitutes for bronze wearing rings. You know bronze is an extremely difficult material to get right now. As a matter of fact, we finally got approval on an A–1–A rating in order to get some local material that happened to be available. That was before we knew we had AA–5 or AA2X. We sent in our PD–1–A and we finally got it back approved.

For about fifteen years we have been using in Toledo on our wearing rings for American Well Works Pumps, an outer shell that is attached to the casing of the pump, in other words, the stationary ring that was formed. It was in a U shape and filled with babbitt. The inner ring that was fastened on the impeller of the pump was doweled on, made of bronze and turned so it was approximately $^5/_{16}$ or $^3/_8$ of an inch thick. Of course, it was trued up. Then the outer ring was poured with babbitt and machined until you had about .015 to .018 clearance between the inner ring and the outer ring.

Now as the original bronze rings wore out and got too great clearance, they had to be thrown away and new ones ordered, which is very expensive. That is why this system was developed, but when the clearance became too great, the inner ring was taken off, a trueing up cut was made on the lathe, then the outer ring was rebabbitted and machine cut taken off of that, bringing the clearance between the two back to the original .15 to .18. This could be continued for anywhere from three to four cuts off the inner ring before it was necessary to cast a new inner ring.

We have saved many hundreds of dollars on wearing rings at Toledo before materials became critical.

The babbitt that you pour into the outer ring doesn't have to be a high-grade babbitt. A real low-grade babbitt, in fact, the cheapest, toughest you can get would be satisfactory. I don't know now whether it would be possible to use lead alone; if I couldn't get babbitt metal I certainly would try it. We never have had to use lead alone in the outer ring. In that way you don't lose any of the babbitt metal except what is worn away. The same way with the bronze, because bronze that is worn away is lost, but your scrap bronze when you get through with your thin ring is still used in melting up for your new rings.

Mr. J. R. Collier (Elyria): I should like to ask Mr. Johnson what steps he has taken to preclude electrolytic corrosion at the sedimentation tank mechanism.

Mr. Johnson: We haven't had any of that trouble so far. However, when I showed these gears and equipment to Mr. Rawn, from the appearance of one of the swivel drive joints he said it looked like electrolytic action. It was in an oil reservoir and it was something I hadn't noticed before. I thought it was developed during corrosion. Apparently during high flow the sewage enters the oil reservoir and while corrosion is present there may be electrolytic action between the steel and the acid in the sewage. Each year it has been our policy to take one of our sedimentation tanks out of service, thoroughly clean it and put two to three coats of different protective paints we have used on it—rubber base paints—and I think by this maintenance work we have eliminated that condition.

Chairman Larson: Apparently you have had some trouble, Mr. Collier. Have you had electrolysis at your plant?

Mr. Collier: We have had considerable trouble along that line. We had considerable electrolytic decomposition of the airlines, the submerged airlines in the activated end of our plant, and we have licked that by simply wrapping the pipe and applying an asphalt paint.

Mr. A. B. Cameron (Jackson): I might happen to help you out on that. We had a lot of electrolysis in what happens to be aluminum, so we went over and stripped them all with zinc, just fastened zinc strips to these plateholders and your electrolysis in the stray currents, would hit the zinc 99 per cent of the time before it would hit the steel. We are making a practice, every six months, of inspecting our tanks and we find the strips eaten up and all we have to do is renew the strips. We buy sheet zinc, cut it into strips, suitably attach it to the parts that electrolysis is hitting, then screw them on with metal screws, and I think that would apply to practically any case of electrolysis where the metal is being eaten away.

Chairman Larson: Mr. Crawford, you are our electrical expert. Does he have his feet on the ground?

Mr. H. V. Crawford: I rather think he has. It is like feeding the rabbits bread to keep them away from your lettuce, but I don't know but what it works all right if he has plenty of zinc around.

Chairman Larson: That is the important thing, but can you get the zinc?

Mr. Crawford: It is on the critical list, I believe and is rather difficult to get. There have been quite a few studies made in my water department and there is a little equipment made in the way of transformer and cathodic set-up that is not too expensive. I don't know if you can get that, but possibly for the duration his remedy is about as good as any.

Mr. Niles: We just got one of those cathodic protectors for an elevated tank. It was just installed a month ago.

Chairman Larson: On the question of corrosion I should like to step out of character a minute and tell you of an experience we had at Springfield. I didn't consider it to be electrolytic corrosion, but it occurred in the straight-line collectors on our secondary tanks. We had a failure of one of our chains and on examining the links we found that at several of the rivets holding the links together, the head had been eaten away and the rivets were backing out, but on examining the rivets we found only the head, that end of the rivet which had been bent over in making up the chain, was corroded. The normal head was in good shape. Now apparently in hammering the metal, the internal structure was disturbed in such a manner that corrosion was—well, it was more susceptible to corrosion than it was in the original state. But I don't know how you would go about correcting that because you have to pin them over almost on the job, but it may be electrolytic corrosion. Of course, in the secondary tank you have splendid conditions with excess of oxygen and virtually no grease for chemical corrosion, too.

Mr. G. C. Ahrens (Omaha): We have noted a severe pitting of wrought iron of the diffusers in our aeration tank and it appears to be electrolysis. We are getting set up now to run some tests to see just how large these currents are in the various sections of the tank, but we have galvanized the wrought iron diffusers in about ten minutes operation.

Mr. Rawn (Los Angeles): In order to diffuse the air through the sewage, we used what this gentleman just stated here, galvanized iron pipes with holes in them for diffusers. The life of those pipes, for your information, in continuous use is about four years. After four years the pitting was so deep the structure was almost completely destroyed. It could no longer be used at all.

As to this cathodic protection, electrolysis is something I know absolutely nothing about except its manifestation, but there is an excellent reference to protection against corrosion and electrolysis in the Sewage Works Journal, which was prepared by a man named Parkes in the City Engineer's Office in Los Angeles, as a result of a situation which developed at the digestion tank on Terminal Island where the manhole cover was to some extent corroded and all circulating water pipes were almost completely destroyed in a term of three or four years. He installed there a system of cathodic protection and with certain types of sacrificial metal as were indicated by Mr. Cameron, and has improved or almost completely cured the condition. That reference will tell you, I think, about how to do it.

SEWAGE PLANT MAINTENANCE IN WAR TIME: ELECTRICAL EQUIPMENT AND POWER SOURCES

By H.Vance Crawford

General Electric Co., Schenectady, N. Y.

Maintenance of the equipment in sewage plants during the war is most vital. Without protection of our water sources from pollution the health of the nation will be undermined—victory may even be jeopardized.

Maintenance is a Big Word in Our War Effort

It is daily becoming more important that we realize this. Since new equipment and materials are needed for the direct war effort, it behooves all of us to make the most of what we have.

Maintenance of sewage plant mechanical equipment has been covered very fully. I wish now to emphasize just as fully the importance of proper maintenance of power sources and the motors and control for your motor driven equipment. Your operators are very familiar with the mechanical units, but not being so familiar with the electrical equipment are prone to let them operate as long as they will hold together.

A little care will eliminate a shutdown in many cases—this is true in most every industry. Although the motor may be considered as an accessory, it is just as important to maintain it properly as it is the big unit which it may be driving. The old saying that "The wheel that squeaks gets the grease" is certainly true with motor-driven apparatus. In other words the maintenance of electrical equipment is decidedly different from most mechanical equipment in that usually advance warning of electrical trouble is not indicated by any sound or by wear, except by close inspection. Usually a machine "squeaks" or indicates in a number of ways misalignment or overload—either by noise, appearance, temperature, or by the quality of its product. Electrical equipment either works or it does not work. Any audible indication of trouble usually forecasts a complete shutdown. In ordinary times this may not be for more than a few hours or at most a day or so, but in war times it may be many days.

Maintenance of electrical equipment in sewage plants is a war in itself—chiefly a war against the elements: rain, sleet, snow, dirt, corrosion, temperature, explosive gases etc. Briefly there are three vital things that can and must be combatted: moisture, heat and dirt. With proper maintenance, wear of electrical equipment can be confined in general to carbon brushes, tips of some contactors, and parts of float switches and, of course, bearings.

In the limited time I have, I will limit myself to these three points, as you are well aware of the protection required against fire, explosions, etc.

Starting with the sources of electrical power, it is usually the function of the power company to maintain this equipment in the proper manner. With the extreme flexibility of electrical power systems, you will not have to worry regarding power not being available for operation of your plant, at least not long enough to be serious. Most of the large power companies are interlocked so that if one source of power should fail, immediate throwover to other sources can be made, or if necessary new wires can be strung and power restored in only a few hours time.

If your power comes from your own engine-driven generators, you are probably already quite familiar with the maintenance required. However, if such equipment is new or has not been operated very long, the first consideration is to keep the temperature within the limits given on the nameplate. Next, keep the windings dry and the oil or grease in the bearings clean.

Watch the brushes as they can wear very rapidly especially if there is much dust in the air. If allowed to wear down too low, the brush-holder will score the rings or commutator and it may be necessary to turn these down, and you may be without power for several hours.

If your engine-driven generators are simply used as a standby, it is very essential that the generator be operated once every week or ten days to make sure that it is functioning properly. Of course, the generator windings must be kept dry.

If your power comes in from the power company through distribution transformers, whether the transformers belong to you or the power company, you should look to the power company for their proper maintenance. They are familiar with the requirements of such apparatus and have all the necessary equipment for making the necessary tests and changes.

Small distribution or lighting transformers require little maintenance; nevertheless there are some features which should be checked occasionally. Excessive overloading is the first thing to check, and here the use of proper instruments is the surest check. For oil-insulated transformers, reading of ambient temperature, load in amperes, and voltage should be taken. Check the oil level as well as the condition of the oil. Moisture may be absorbed and samples of oil should be tested both from the top and the bottom. Self-cooled transformers of the larger size should be tested probably once every six months; for the smaller sizes, probably once a year will be sufficient. Proper ventilation is essential.

The loading on transformers can be increased by improving the ventilation and by adding fans to circulate more air around the radiating surface. However, before attempting to increase the capacity in this manner, a check should be made with the manufacturer to determine if this is feasible. Recommendations for safe overloading have been established by the American Standards Association and N.E.M.A.

It is important to check regularly the condition of any spare transformers if they are to be depended on for service in case of an emergency.

It should not be necessary to call attention to the fact that the bushings must be kept clean or the deposits may result in bushing arc overs. Transformers also should be kept well painted to prevent corrosion of the casings and other metal parts. Conduit pipes leading from the station to the terminal boxes at the transformer should be sealed to prevent warm air from flowing into the box and condensing.

The necessary switchgear required for connecting the transformers to the power line as well as for distributing the power from the transformer requires only a minimum of maintenance, but periodic inspection and some servicing may be necessary if it is to function properly at all times. In all probability inspections once a year in most cases will suffice in sewage plants where this equipment is operated infrequently. Also in general this equipment is located in a warm, dry room under such conditions that very little maintenance is necessary.

The height of the oil in oil circuit breakers must be inspected regularly. If the switch is operated frequently or has been subject to operation under a heavy overload, the oil may become badly carbonized in which case it should be either filtered or renewed. Bushings or potheads should be kept clean or they may become gummed with dirt and cause a flashover and serious damage and delay.

Motor maintenance is the chief thing to consider in a sewage plant because a great many of them must operate under the worst possible conditions. If they are not applied properly, trouble can be anticipated at any time. If, however, the motors are of the right size, proper characteristics, and construction, you do not need to worry too much if you maintain them in a reasonable manner.

If you are not sure that the right motor has been applied to each process, the sooner you determine the fact, the better it will be. Just because your motor has been operating a number of years without trouble is no proof that the insulation has not been heated too much or not enough, or is not covered with dirt, oil, or grease or that the oil or grease in the bearings is not in bad shape. The motor may be right on the point of breaking down thus requiring complete rewinding or new bearings. If the motor is operated too long after a bearing failure, it may be necessary to rewind the motor completely as well as supply new bearings.

In general, the two most important things to protect in most sewage plant motors are the insulation and the bearings. The insulation may be overheated or cooked due to the motor being located near a heater incinerator, dryer, or from overload. If the heat is from an outside source, fans should be installed or insulation barriers erected. If the heat is from the motor's own load, proper steps should be taken to reduce the load. In the latter case, a load test should be made on the motor. The control should also be checked to see that it is set to give the proper protection.

It is exceedingly important that the bearings not be over oiled or greased as the oil or grease may flow or be sucked over the winding or commutator rings and brushes and cause a great amount of trouble.

If the motor is operated very infrequently, it may be that the windings have been deteriorated by moisture; the insulation resistance should then be tested.

Proper procedure along this line is to measure the insulation resistance of the stator winding with an insulation resistance meter. If this shows a value less than rated voltage divided by (0.75 times HP rating) plus 1000 megohms, the motor should be removed from service some time during the day or night and dried out if moisture has accumulated in the windings. The motor can be placed in a room or oven or under a piece of canvas with a heater and held at a temperature not not exceeding 90° C. until the insulation resistance becomes practically constant. The motor also may be dried out by passing a current at low voltage through the windings.

The above procedure should always be followed in starting a new motor, especially if the motor has been standing for some time either in storage or after installation. This is especially true of motors installed out in the open.

Failures other than from moisture are usually caused by dirt, oil, or grease. Ordinarily motors around sewage plants are not affected by dirt accumulation except those motors which may be installed where sludge or garbage is disposed of in an incinerator, or where the sludge is dried and shipped as fertilizer or burned under a boiler. In such cases, motors can be cleaned with compressed air at not too high a pressure, but the preferable method is to remove the dirt accumulation by suction rather than pressure, using a suction or vacuum cleaner with a long rubber nozzle. In some cases, continual cleaning by blowing is apt to cause the dust to pack tighter in between the coils and if there is a high metallic content, trouble can be expected sooner or later. Also compressed air may be saturated with water.

For motors in dusty locations as mentioned above, it is well to take the motor out of service for general cleaning. The windings should not only be rubbed free of dust, but a soft brush wet with carbon tetrachloride should be used to remove all traces of dust. This fluid is exceedingly volatile and if it is not applied too freely will not injure the insulation. After this process, it is well to dry the windings as previously mentioned. When the windings are dry and still warm, an insulating varnish of the best type should be painted or sprayed on. With the smaller motors dipping is even better. The motor will then have to be dried again; depending on the kind of varnish used, the drying period may extend from an hour to six hours. If baking is necessary, the temperature should not exceed 90° C. If the windings are in poor condition, it may be necessary to apply two or three coats of varnish.

If the motor is a type that has a commutator or collector rings, it is of course very important to keep these parts clean with polished surfaces and a good fit between the brushes and the metallic surfaces. Dirt, copper or carbon dust, or oil or grease should not be allowed to accumulate between the segments or on the shaft between the collector rings.

Bearing Maintenance

Bearing maintenance is an important detail, and periodic inspections will indicate the wear that is taking place, especially if an accurate record of each motor inspection is maintained. Every motor is designed to have a certain air gap between the starter and the rotor, and if a tapered air gap gauge is less at any point than the minimum values given for a specific motor, it is an indication that the sleeve bearings should be replaced. Measurement of the air gap of the ball-bearing motor is not necessary, since this type of bearing will usually indicate trouble and become inoperative with a small amount of wear and long before any change in the air gap can be noticed.

Motor bearings are no different from other bearings, so that frequent renewals of the oil need not be stressed. The operating conditions and length of time the motor is operating determines how often oil should be added or when the bearings should be cleaned and new oil used.

With grease-lubricated, ball-bearing motors, grease additions are determined by the severity of operation, both as to length of time and cleanliness. The bearings should be equipped with fittings for adding grease and expelling grease through a release plug when the bearing becomes full. It is well to add grease while the motor is running, and sometimes it is well to add new grease until all of the old grease runs out the release hole.

It should, of course, not be necessary to emphasize the important point of thermal protection by both overload and short-circuit protective devices. These devices should be inspected and if there is an indication that the motor is overheating, a thermometer should be placed on the motor with the bulb encased in soft putty, and at the same time current and voltage readings should be taken to indicate whether the motor is heating from overload or from poor ventilation, or possibly a high resistance ground.

All of the above applies to open motors as well as totally enclosed or explosion-proof motors. However, motors of the totally enclosed or splash-proof type should have all of their joints sealed to prevent seepage of water through to the windings. This, however, is not always done, and if on close inspection there is indication of leakage of this kind, the motor should be disassembled and all the joints properly sealed. The sealing should be done with some kind of compound containing graphite so that in case repairs are necessary the motor can be disassembled readily.

Control

Control equipment can be quite simple or very complex and the first consideration in its maintenance is to be sure that the operating force has available a complete set of instruction books and wiring diagrams covering every piece of electric equipment, and every circuit. Necessary spares should be available as well as a complete list of spare parts. The operator should be familiar with all of his control circuits and with the possible sources of trouble so that failures can be located quickly. He should also have suitable instruments for checking voltage, current, and resistances not only of the electrical circuit but of insulation.

The first consideration in maintaining control equipment in proper working condition is to prevent an accumulation of dirt, oil, or water. It is therefore advisable to carry in stock protective paints for the stationary iron parts, and insulating varnish of the proper characteristic for the coils. In a sewage plant in particular where special consideration has not been given to the kind of control installed and to the method of installation, it is well to inspect and paint the various control parts from two to four times a year, depending on the severity of the operating conditions.

All moving parts should be operated by hand and adjusted so that they line up properly. All wiping or contact parts should be adjusted to give the proper contact surface. If the tips are black this is an indication that copper oxide has formed and this should be sanded clean. All relays should be adjusted very closely and if they are of the time-delay type, with bellows or dashpot attachments, particular care should be taken to see that they are in proper working order. Certain types of oil are required in maintaining the bellows or the dash pot should be flushed out removing any sediment which may have accumulated.

All circuit breakers or contractors are usually of very rugged construction. Still they should be operated by hand from time to time and checked to make sure that all of the clearances are normal and that the parts work freely. Adjustment or renewal of the tips is necessary and depends on the frequency of operation and cleaning depends on the copper oxide formation. Close inspection of any pigtail connections should be made as these corrode very quickly in a sewage plant and may actually fall apart.

Instruments, of course, should be sealed to prevent dirt and moisture getting into the delicate parts. They should be checked for accuracy at least once a year.

Float switches which govern the automatic starting and stopping of the pumps should be given the best of care. If they are of the moving contact type, the tips should be adjusted and lined up properly and of course polished and filed if any indication of excessive corrosion is noticed. The bearings should be made free to operate and any tendency toward binding should be corrected.

If the float switch is of the mercury contact type, the mercury tubes should be held tightly in place. On inspection if tubes appear dark, it may be an indication of air leakage. In such cases, the tubes should be renewed. The connections from the tube located on the shaft should be covered with a coating of lacquer to protect the leads from corrosion.

The float wire chain or tape should have a minute inspection once a year to determine if any excessive corrosion is taking place. If this is found to be the case, these parts should be repaired or renewed throughout their entire length.

Two or three times a year it is well to lower a light down the float tube or make sure that there is not an accumulation of solid matter inside the tube. The float, if made of metal, should be inspected and tested with the fingers to make sure that a weak or thin spot has not developed.

Bombing protection consists chiefly of protection of the switchboard and control from dust, dirt, and flying glass. It is considered advisable in some cases to build a plywood room around large central control boards with a number of sections of the walls opening out away from the board so that proper ventilation may be obtained.

Follow the "K" schedule if you would have your electrical equipment maintained in the best possible manner.

Keep it dry.
Keep it clean.
Keep it properly lubricated.
Know its condition at all times.
Know that its load is not beyond its "Kapacity."
Korrect the weak points before failure.
Keep a regular inspection record.

Let's listen to the Don'ts—

Don't expect your electrical equipment to keep on operating without proper inspections and maintenance.

Don't hesitate to call in an "expert" if you have been having trouble or if your equipment has never been really inspected.

Don't let just anyone work on your electrical equipment, be sure he knows his business.

Don't think, however, you have to have in every case the actual manufacturer of the equipment work on it. Get the nearest reliable help you can obtain.

Don't send in your motor or control to the manufacturer before having them tell you to do so. Phone or wire the nearest office.

Don't run your motors without knowing how they are loaded.

It's better to operate part time and let them cool off if they are overloaded than to keep them going until they burn out.

Discussion of Paper by H. Vance Crawford

Mr. Morris M. Cohn (Schenectady): May I say just a word about the general aspects of Mr. Crawford's paper? I think it is particularly valuable because in our scheme of knowledge in sewage treatment a great number of us are a little bit scant on electrical knowledge. I have always felt that some of our knowledge on electricity is very much the same as the farmer lady who came into town and stood at the busy corner watching the electric trolley cars go by. Finally the traffic cop came over to her and asked whether or not she wanted to cross the street. She said she did but she was afraid she would get her feet on the trolley tracks. He said, "Lady, you can't do any harm to yourself unless you reach up and put your hand on the trolley wire." That is about the extent of some of our knowledge and the phenomena of electricity.

So I think Mr. Crawford's paper is particularly valuable at this time.

The maintenance and care of electrical equipment has always been an important matter; has become particularly so since the trend toward mechanization that we heard Mr. Dorr talk about this noon, because without doubt the electrical equipment is the heart or perhaps the soul or perhaps the nerve center of these electrical devices we have impressed into sewage treatment service. It gives you a very queer feeling when suddenly something goes dead and you can't find it because of that dead condition. Sometimes you can't tell whether your equipment is going to fail or not. Mr. Crawford made a very important point when he said that in mechanical equipment very often you get some type of warning, whereas in the electrical equipment field you don't. It either runs or it doesn't run, and sometimes it fails to run at the most inopportune moments. Perhaps I have a very homely example of just that point.

About fifteen years ago we had occasion to rewire the lines leading up to a five horsepower sludge pump at the Schenectady treatment plant and the electrical inspector came down and looked the job over before he approved it and we happened to show him the five horsepower motor that was doing the job. The motor looked pretty bad, I am willing to admit. It was located in a very bad spot, subject to the dust and moisture conditions that Mr. Crawford described. The motor looked as though it were on its last legs and he very frankly said so. That was fifteen years ago and that motor is still in operation, perhaps because we have given that motor scrupulous care and have done about everything to it that the paper by Mr. Crawford recommends.

On the other hand, we have a refuse incinerator in town—which you might have guessed from my questions to the priorities expert this morning—where we have experienced a motor burn-out. That motor looked perfectly all right before it did burn out. In fact, just the afternoon before it failed we had an electrical man come down and check some of the control equipment operating that motor and, strange as it may seem, that motor failed the following morning because we failed to do some of the things that were mentioned in Mr. Crawford's paper.

I mention that as a very interesting example of the truth of the statement that you don't get too much warning of failures. Sometimes the outworn appearances mean very little, as in the case of the motor that is still running after fifteen years of condemnation and as illustrated by the motor that failed within a few hours of service after an electrical man had carefully checked it. He failed to check the brush holders. The holders had badly gummed from the presence of oil and fly ash from the incinerator pit and once the brushes got out and failed to drop down, the motor single phased long enough to burn out the end clips on the motor, and it went completely to pieces.

May I say that the experience we had for two days at the incinerator is a pretty good indication that you don't get equipment over the counter today. We had serious difficulty in getting that motor onto the production line in a factory that was operating exclusively on army and navy schedules with priorities up into the almost infinitesimal figures. We walked in with an A–1–J at the moment and they smiled very graciously and said, "Well perhaps we can fix you up after the war but not right now." You just can't get equipment over the counter, which brings me by round robin back to the original statement I made that now of all times is the time to take care and maintain equipment very scrupulously.

We have had difficulties with float switches but who hasn't? They are subject to a number of ills. Those ills can be minimized by proper care, by proper diligence, but they are subject to a great deal of mechanical wear, a great deal of binding and grabbing and locking because of the materials that are being pumped. The presence of debris in the sewage makes the operation of a mechanized float switch somewhat difficult, to be sure.

I hope I am not divulging any internal secrets when I tell you that within the past six months or so we have been working with Mr. Crawford on the development of a level controller operated by this magical force we call electricity, which gives promise of being the answer to the operator's prayer. I hope it is going to work out that way.

May I again commend Mr. Crawford on a very practical paper and I, too, feel that the thing should be published in SEWAGE WORKS JOURNAL.

MR. HAROLD R. FANNING (Eclipse Machine Division, Bendix Aviation, Elmira, N. Y.): I would like to ask Mr. Crawford if he has any suggestions on how to keep float switch electrodes from grounding.

MR. CRAWFORD: Well, I have seen very few of those. From those that I have seen I am surprised that they don't ground more often than they do. In other words, I was in our fire station in Schenectady not so long ago when they had a program of fire prevention and they had a trophy case full of cups and so forth. They wanted a light in there so they took some of this cheap fixture wire, had some wire around the wall and through a hole in the case which they made with a penknife, and that is the way they wired up the trophy case.

The trouble with your electrodes I think is the way they are wired up. The ones I saw just recently had the smallest, cheapest kind of wire you could imagine and I was surprised that they hadn't grounded before. They had only been in operation a year or so.

MR. FANNING: As a matter of fact, this plant had only operated about a month before we had trouble with the electrode grounding. Do you recommend floats instead of electrodes?

MR. CRAWFORD: Not necessarily. I would cover my float tube. I would have an entirely different cover with some porcelain insulators in the top of the cover, with the wire coming down the wall in conduit and a heavy wire with rubber over it coming down and looping over so there wouldn't be any question about the wires getting grounded. Be sure the end of the conduit is plugged with tar or similar material to keep water vapor from condensing in the pipe.

MR. FANNING: The wire is in conduit but upon examination I found shortly above the electrode itself the wire was exposed where the metallic substance would get up into the conduit. It is almost impossible to get it out, whereas at the bottom of the electrode you could clean it.

MR. CRAWFORD: All you need is a good wiring job.

MR. ENLOE (Atlanta): I would like to ask Mr. Crawford a question. I recently heard an electrical man state if you had a coil in a motor grounded you could jump that coil and leave it in there in preference to replacing it by some method of sawing this coil in two, and continue operating the motor in preference to damaging the coil and replacing the shorter coil.

MR. CRAWFORD: That can be done in emergency many times. Many times the coil has been shorted out.

MR. ENLOE: How do you do that?

MR. CRAWFORD: You have to be sure the wire in this coil is separated from the rest of the coils and also from the ground; by playing around with a drop light you can pick up the loose ends, cut the coil out and then run a loop around from the loose ends, insulate it properly and you can run that way. But, of course, you should get it rewound just as quickly as you can.

Mr. Enloe: He stated in rewinding you would probably damage the other coils more and do more harm than you would good in replacing one coil, and stated he had motors in operation two or three years that had one coil and sometimes as many as two or three of the coils supported and looped around.

Mr. Crawford: Well, of course, I failed to call attention to the fact that the type of winding has a lot to do with it. If you have a random wound motor, you really can't take out the coil, and if you have a former wound coil, where they are baked and simply placed in the slots and the ends collected, you can do that. On a random wound coil you might get into a lot of trouble trying to take out some of the wires, because they go back underneath and twist around and come out on the top. That is the reason they call them random wound. You will probably run into a lot of difficulty with a random wind. Most of the motors of larger size are former wound.

SEWAGE PLANT MAINTENANCE IN WAR TIME: MAINTENANCE OF GROUNDS

By A. B. Cameron

Supt., Sewage Treatment Plant, Jackson, Mich.

The sewage treatment plant of Jackson, Michigan is located about one mile north of the city limits immediately adjacent to U.S. 127 which is one of the main traveled roads of the state. The site covers approximately 55 acres and is bisected by the Grand River whose head waters are just south of the city. The river at the plant is very shallow and about 30 feet wide with a mean discharge of 79 second feet during 1941.

The plant is of the activated sludge type using compressed air from motor driven Ingersol Rand rotary type compressors. Construction was started in 1934 and finished late in 1936. Funds were derived from revenue bonds and construction was under P.W.A. The design was handled by Fargo Engineering Company of Jackson with Gascoigne and Associates of Cleveland as consultants. In passing we can say that design and construction both were of exceptionally high quality.

The grounds may be divided into two parts, those immediately adjacent the structures which were rough graded with materials from excavation without the use of any top soil, this area being approximately 20 acres. The balance of the grounds were left in their natural state and embraced a marsh of about 20 acres in the middle of which was a spoil pile containing about 30,000 cubic yards of rock and shale from excavation. The entire area was fenced in with standard industrial fencing with two entrances at opposite corners of the plant.

W.P.A. Projects.—The plant was placed into operation December, 1936, and in the spring of 1937 a start was made in landscaping the grounds by means of W.P.A. projects. The writer has been of the opinion for a number of years that attractive grounds and a clean, well maintained and orderly plant are tremendous assets in selling sewage treatment to the general public and city officials. We believe the average layman judges the efficiency of a treatment process much more by the appearances of the plant and grounds than he does by the appearance of the plant effluent and a mass of statistics which, to the layman, are generally just so many figures and percentages. Regardless of how glowingly we operators may talk of how well the plant is working, the writer is convinced that no amount of talking or figures will offset the poor impression that visitors receive from barren and desolate grounds or poor and slip-shod housekeeping. We are further convinced that due to the nature of the materials dealt with, more care along these lines should be exercised than at water plants and other public utilities about the country. Another very worthwhile result of the above outlook is reflected in the exceedingly high morale obtained with all employees at the plant. Without any exception, we believe every employee at the Jackson plant is proud of the plant and the fact that he is working there; this in turn means that each man is a booster for the job and his individual output is higher in terms of work, initiative and interest in the job.

With the above opinions and ideals in mind, plans were prepared for an extensive landscaping project which would cover an indefinite period of time but always having in mind the final results desired. The first step was to employ a competent landscape architect who prepared drawings covering the entire site. The scale used in the drawing was 1″–20′. In general the architect received instructions to use hardy trees and shrubs, preferably natives of Michigan; by suitable arrangement, a rotation of bloom and berries could be obtained. It was stressed that types should be used that required the minimum of upkeep and maintenance. Originally no flower beds were included in the plans. All berms and digester slopes were planted with low growing shrubs instead of lawn seed. After plans were completed and approved by the City Commission, a W.P.A. project was sponsored covering the grounds immediately adjacent the plant structures. Later another project was sponsored covering the area immediately along the highway, and the construction of 30,000 square feet of additional open sludge beds. In this project the spoil pile was removed, the rock being utilized for runway construction at the local airport, the entire area was underdrained with field tile. The plot was graded into gentle rolling lands and two lagoons were dug, the earth from this excavation being used for fill where required and the riprapping of the Grand River within the plant area. Stone for riprapping was obtained from sidewalk replacement and pavement that was being replaced, and other small items of general landscaping. Later a third project was sponsored which covered the construction of two additional digesters, the construction of a sludge lagoon, the construction of a softball diamond, an extensive rock garden and other small items of landscaping about the plant. Still a fourth project has been sponsored covering the landscaping of the grounds about the new digester and the reforestation of about 10 acres in one corner of the grounds. This last project will have to be held in abeyance for the duration.

Time does not permit us to go into detail regarding many features of the grounds but we do wish to point out some of the high spots.

1. A softball diamond that is in constant demand.

2. Two lagoons that are flood-lighted and used during the summer to support a flock of about 50 mallard ducks. During the winter these lagoons are used for skating.

3. A rock garden in which is planted yearly about 1500 plants, snapdragons, zinnias, phlox, salvia, etc. Many bouquets of flowers are donated to the various hospitals about the city from this bed.

4. Two miles of roads both paved and graveled have been constructed and about ½ mile of walks has been built.

5. The entire area is underlaid with a sprinkling system that has an output of 1 million gallons per day and reaches every part of the plant. This is equivalent to 1″ rainfall in 8 hours. Settled final effluent is used as the source of water supply so we really fertilize as well as sprinkle as our effluent generally runs about 8.0 p.p.m. nitrate nitrogen. This system is also used during the fall for spraying waste activated sludge about the grounds as required.

6. No top soil was used, we made our own from the sand and clay about the plant properly mixed with digested sludge. We estimate that we have used approximately 6,000 tons of sludge in making this top soil.

7. Picnic tables have been built and charcoal grills installed for use by the general public and we find that these are in great demand. In fact they generally have to be reserved to avoid disappointment.

8. Approximately 10,000 shrubs and 1,500 trees have been planted in the area and there are over 150 varieties.

9. Six men are employed for a period of the six summer months who work exclusively in the grounds and we feel that this investment in labor of about $4,000 pays us a very big dividend in good will, increased efficiency, etc. Many times we hear the remark that the grounds are the most beautiful in the city and several times editorials have been printed suggesting some other name than that of sewage treatment plant.

Total costs of the three W.P.A. projects completed to date have been $330,000, and of this $100,000 was for plant additions, thus leaving a net W.P.A. cost of $230,000 for grounds proper. The fourth project which will complete the entire program is small, only totaling about $20,000.

The writer has many times listened and taken part in discussions wherein the advantages and disadvantages of having the sewage plant grounds used as a recreational center were discussed. Experiences to date indicate that the advantages far outweight the disadvantages at Jackson. As noted elsewhere in this paper, the general public of Jackson are very well satisfied with the plant and this is reflected in the fact that very few complaints are made when the current bills for service are paid. Several of the elective city officials have mentioned to us that they never hear of any complaints about either the plant or monies spent at the plant; likewise, the City Commission have always been very willing to go ahead with any desired improvements required or suggested and during the past five years not one request has failed to be O.K.'d by the City Commission. This, I believe, is somewhat of a record in the annals of sewage treatment plant operation.

No attempt has been made to keep track of the number of visitors as the grounds are spacious and many people come to the plant and just drive around, others visit the lagoons and feed the ducks, play ball, etc., and never visit the plant proper. We do know that the ball diamond is in constant use as that is always allotted by reservation; also we know that the grills and picnic tables are generally used daily during the summer months.

Regarding abuses, we have perhaps been fortunate in that most of our visitors have been very well behaved. Some trouble has been experienced with children running about the edges of the various tanks and coming into the plant buildings but these have been minor and haven't been of enough consequence to warrant the locking of outlying buildings. Another nuisance has been speeding about the plant driveways at night which endangered the operators as they made their rounds. Very little trouble has been encountered in the scattering of trash or rubbish resulting from picnics so all in all we have very little indeed to complain about. The only trouble we have tried to correct was the speeding in the plant grounds and this was effectively remedied by the installation of numerous "Slow" and "Stop" and speed limit signs and by a simple resolution by the Commission closing the plant grounds to the public between the hours of 10:00 P.M. and 6:00 A.M. each day. During these hours the grounds are closed by locking the gates at each entrance.

With the outbreak of the war the question naturally arose regarding protection of the plant and appurtenances against sabotage and wilful destruction of the properties by alien enemies. This question was discussed several times and resolved itself into two views. First the likely possibility of sabotage and the necessity of taking adequate measure of protection against this possibility; second, the possibility that there was little, if any, likelihood of sabotage. The second reasoning was based upon the fact that outside of the health angle the operation of the sewage treatment plant had little, if any, bearing upon the war effort as the failure of the plant to operate would not shut down any vital industry as would be the case in failure of the water or electric systems. The main effect of any sabotage at the plant would be the possible diverting of needful materials to effect repairs, etc., from more vital industries and if this was the only possibility, it would be a very roundabout method of accomplishing an objective. Incidentally, the writer held to the second viewpoint.

However, as a matter of precaution it was decided to act upon the first assumption and with this in view the City Commission by resolution closed the plant to the public for the duration. The effect of this order was far from satisfactory. First, the public was used to using the park and recreational features of the grounds, particularly the ball diamond. Second, the public was used to obtaining quantities of sludge within the ground areas. Thirdly, it meant a lot of inconvenience to plant employees and others having official business at the plant proper. As noted elsewhere, the plant grounds are completely fenced in with two main gates which are located some distance from the office. When people having legitimate business wanted access to the plant it meant sending a man some distance to unlock the gates and again lock them when the party was leaving. The sludge question was more or less settled by building a stockpile just outside of one of the gates, but it certainly was surprising how often this pile became depleted and of course this all meant handling the sludge twice with increased costs for these operations. It would appear that if this system were to be continued in effect, it would be well to post a guard at one gate for certain hours of the day. This too would add to costs, etc.

After several months' trial of the above procedure, it was decided to adopt the second assumption, namely, that there was little, if any, danger of sabotage. Again by act of Commission the previous resolution was repealed and the plant again placed on regular peace-time regulations that had proven to be so successful in the past. These are still in force and the writer is of the opinion that we will continue on the latter basis for the duration.

In connection with the possibilities of future troubles from sabotage we have set up the following schedule that could be put into effect within a very short time and which would prove to be effective we believe.

First close all grounds to the public by locking of the gates.

Install and operate the following:

Water tower	$ 300.00	
20 flood lights installed	1,000.00	
Total		$1,300.00
Operating Cost Per Month		
4 guards at $100 per month	$ 400.00	
Additional power	60.00	
Maintenance	40.00	
Total		$ 500.00

The writer doubts very much if we ever will have to adopt the above procedure.

In closing, the writer wishes to acknowledge and thank the personnel of the plant for their interest and many valuable suggestions, Mr. W. L.

Blackmar, who was employed as landscape architect during most of the W.P.A. projects and who did a very good job. We wish to pay special tribute to Mr. R. B. Jackson, plant engineer, for his tact, unfailing interest and devotion to the job during this period. Mr. Jackson was in direct charge of the plant for all construction and landscaping in addition to his regular duties.

Discussion of Paper by A. B. Cameron

Chairman Larson: Thank you, Mr. Cameron. Apparently you have a plant which has gone the whole gamut from alpha to omega on the question of protection. Certainly there are those of you who will disagree. That is what we want—some disagreement. What do you think about it?

Mr. S. E. Coburn (Boston): I am on the other side of the fence somewhat. I believe that sewage treatment is a business and a serious business. I like to see a well-kept, trim plant and I have just one question which sums up the whole thing. I would like to ask Mr. Cameron if he is superintendent of parks or superintendent of sewers?

Mr. Cameron: I might answer that by saying a combination at the present moment, but primarily sewerage. I don't pay much attention to the grounds myself. I think, Mr. Coburn, you get our reports and know that the records indicate we are not neglecting the plant proper for the grounds.

Mr. Coburn: I don't want to start a controversy over this but if it is the combining of two city departments, which we are all looking forward to, unification itself is a fine thing, but if you are charging up against the taxpayer money for recreational and park purposes and charging it to the sewer department, well— (Laughter.)

Mr. Mathews (Gary, Ind.): I wish to commend Mr. Cameron and his board for the attitude they are taking in this matter, but there was one thing that wasn't mentioned, and that is the legal responsibility that you are assuming when you allow people to ramble through your grounds more or less at their pleasure.

We were bothered considerably by boys on bicycles coming into our grounds. There is an old highway that goes right through the center of the plant site. We fenced off one end of it and put gates on the other, and left them open until the Board of Works got this abandoned highway closed through a reservoir on a dedicatory process. On consulting with the attorney at the Board meeting one day, we found it was necessary for us to put signs on all of our tanks showing the depth of the water and asking the people to please walk carefully, and to post a sign at the entrance stating that children under eighteen years of age would not be admitted unless they were accompanied by a parent or guardian. Then when the war came there was further discussion as to the possibility of sabotage. Well, anyone who knew enough to get into Gary and wanted to do any sabotage work certainly wouldn't pick out the sewage treatment works. If they did put us out of business, they might create some situations which wouldn't be so healthy.

The Board adopted the principle of leaving the grounds open from one end only from sunrise to sunset, and we welcome visitors during the day just the same as any other time, only they are never allowed to be by themselves. We furnish a guide. We can always draft someone to take them around.

Our sludge business is pretty important, not from any money received but from the benefits we receive from having people remove it right from our beds free of charge.

Chairman Larson: You never admit that to them, Mathews?

Mr. Mathews: Certainly, we admit it. We tell them we make $40 a ton more by the load than if they buy from the local agent. I happened to look at the sludge book just before I left, and there were some 4,500 registrations so far this year on customers. I don't know how many visitors we had but all last year we had 388 visitors that actually weren't from Gary in a town of over 100,000. So we want to encourage our sludge customers. Let them come on Sunday or Saturday afternoon to haul sludge and we will take care of what few visitors apparently are interested in the plant. We have ten acres of lawn to take care of and there are plenty of shrubs around there so the site presents an attractive appearance, we hope, but beyond that we are not interested in any ball games or picnic grounds or barbecue parties out there.

Mr. T. C. Schaetzle (Akron): Mr. Cameron stated that the operation of a treatment plant will have no effect upon our war effort except as it is related to public health. I am wondering whether he meant that with respect to the Jackson plant alone or whether he looked at it in a broader light. There are some treatment plants discharging to bodies of water where the water from those streams is used for war industries at points down below. I am just wondering whether you were thinking of Jackson or overlooked that viewpoint.

Mr. Cameron: Of course, that applies particularly to the Jackson plant, but from my general knowledge of plants about the country, I think the same statement would apply to approximately 90 per cent of all plants. Of course, there are always exceptions.

Mr. Schaetzle: My only fear is that if we only talk about it from a public health standpoint we might have difficulty with priorities, and we do know there are other elements that enter into it in some cases.

I had one more thought. We are talking about protection for treatment plants. Naturally, I am thinking of the plants with which I have had most intimate connection, and by way of remarks, I can say they are the Baltimore plant and the Akron plant. In neither of those cases would complete protection of the plant proper do a great deal of good, because if anybody wanted to put a sewage plant out of existence, all they would have to do is bomb it out on the sewer. They are both susceptible.

Mr. Cameron: That condition exists. We have three lift stations about the city and I think about 75 per cent of our sewage is pumped up to lift stations three or four miles away. If they really wanted to put us out of commission, they would blow them up.

Mr. Rawn (Los Angeles): This matter of bombing brings up the question which I wanted to discuss this morning but there wasn't time. I wanted to take issue with the gentleman from W.P.B. who stated there wasn't any danger of sabotage. Now that the opening is presented again, I want to just make this remark.

In the western United States and particularly in the extreme western States of Oregon and Washington and California, there is a very strong opinion that all sewers and particularly large storm drains and large sanitary sewers which lead to the vicinity of strategic plants must be so protected that saboteurs can't enter them or float materials down which float out near these or at these particular plants. That feeling is so strong in western United States that there is one individual commissioned from the United States Public Health Service, from that department who is looking into that feature alone, and the Governor has appointed a committee which is presumed to take cognizance of all places where sewers of large diameter or large dimension flow at or near strategic war plants or cantonments.

I wanted also to call to your attention one other thing which is a little bit out of the line of discussion, and that is in one of the moderate-size cities in the vicinity of Los Angeles there has been a very definite effort which was successful to sabotage a sewage pumping station. In this instance, caps, perhaps not fulminate of mercury but caps of considerable strength, were introduced into the pump suction, probably came from some point upstream and in revolving in the volutor case they apparently struck a little outlet valve at the top, which bled off the air, and two pumps were almost completely destroyed in that pumping station.

Now they know it wasn't done by any cracking of the pump case by water hammer or valve slam or anything of that kind, or something getting into the pump impeller; it must have been by an explosion by the appearance of the water marks on the inside of the case, for one thing, and because it happened right before the eyes of the pump operator, in the second place.

I was inspired to get up and make these remarks by the fact that some of these gentlemen were talking a little bit about bomb protection. I don't think you can protect a plant from anything unless there is never going to be an airplane fly over your plant.

One other thing that I am inspired to say also and perhaps you have heard it before is that one of the most beautiful parks in the United States—now, of course, I am bragging about California—is the Golden Gate Park in San Francisco. That is a pretty hard thing for a man from Los Angeles to say, but it is one of the prettiest parks in the world and that park is responsible for its existence to street sweepings and sewage. It was built upon sand dunes. The ground was stabilized by street sweepings and by sewage run out over the area. There was an article about it in the *Saturday Evening Post* three or four years ago and everything I think except that was mentioned. About a half mile up from the east end of the park is an activated sludge plant that was placed in operation to provide the water supply for the park itself, and the lagoons which you will see in there and the babbling creek and runs and rills all populated by ducks and geese and black swans and so forth, are nothing else than the effluent from activated sludge plants situated near the center of the east end of the park which provides not only the water supply for the park itself but substantially all the fertilizer that is used there at the present time.

CHAIRMAN LARSON: Thank you, Mr. Rawn. That certainly merits the repetition of the statement that it can happen here, gentlemen.

MR. VAN KLEECK: Mr. Chairman, to add to Mr. Rawn's remarks about the protection of sewers, I happen to know in the New Haven area that a survey has been made of all the war industries there and all manholes in the mill yards have been equipped with locked covers and any overflow sewers that are large enough for a man to enter have been protected with bar screens encased in concrete.

CHAIRMAN LARSON: Surely someone could take issue with this implied statement that our sewage plants won't be missed if they are bombed out of existence.

MR. JOHN W. JOHNSON: Mr. Larson, in our plant in Buffalo we are situated on an important water course. On one side we have Niagara River and on the other Black Rock Harbor, and it is part of the canal system. When war started, our Board saw fit to take steps to protect the plant because of its being in a vital water front area. They were only about a week ahead of the United States Government in wishing to protect the canal, and went after us and had us change our revision of the fencing to include a larger area. They have also insisted that we keep all persons from entering our plant except on official business.

We also have a similar case to that which Mr. Van Kleeck talked about. The government has come in and installed at their own expense gates in the larger sewers that serve the defense plants. As soon as we closed the plant—it is quite a place for people to come down and watch the river flow by—we had numerous complaints and many of them from the Sportsmen Clubs in the city. It seems that Bird Island is the best spot in the whole city to obtain fish for bait and they finally were issued temporary passes, and at the present time have access to the plant only in the daylight hours. I never knew there were so many men who were interested in bird life. At the present time we have issued passes to four of them who formerly used to shoot rare birds for historical societies and now are substituting firearms for cameras, because the United States Government has guards at both the south and north end of our plant. We have a guard in service 24 hours a day at the gatehouse at the main entrance. We have a short-wave radio system and we have a man on our switchboard 24 hours a day. In several blackouts we have had and in the incident demonstrations, the effectiveness of this program has been most gratifying.

MR. ROY L. PHILLIPS: May I say something on a little different subject from Mr. Cameron's paper? I wonder how many have taken advantage of the opportunity, where you lack money for the beautification of a sewage treatment plant, to develop your own nursery. We have found an investment of $500 in very small evergreen shrubs will grow into thousands of dollars in a period of three, four and five years. We either have transplanted or are engaging in transplanting thousands of dollars worth of shrubs that originally cost us $500. I don't know of any place where you have more land of the proper kind to grow shrubs than around a sewage treatment plant.

Mr. Enloe (Atlanta): Instead of paying money for the shrubs, why not pay sludge? We bought over $500 worth of shrubbery with our sludge, and are growing it.

Mr. Niles: I don't think Mr. Barnes of Bowling Green is here but I might say at the Bowling Green, Ohio, plant they have quite a nursery established in which they have developed this same idea that was just mentioned of taking small trees and growing them until they were ready to transplant. They have a regular city nursery in their plant.

Mr. Roy L. Phillips: I might add just one more thing, Mr. Larson. We have also planted shade trees on our sewage plant property at a very small cost, very small trees, and are pursuing the policy at present of giving the trees in new residential districts where people are developing and building homes if they will pay for the proper setting out of the trees under our care. We have uniformity of street tree planting and development. They cost us about 15 cents apiece when we buy them. They think they are getting something and will take great care of them.

Chairman Larson: In defense of Mr. Cameron's cleaning up and in answer to Mr. Coburn's implied accusation that he may be neglecting his operation, I have a feeling and I have always felt if a man has sufficient interest to keep his place looking well or if a chemist keeps his laboratory cleaned up, it is a pretty good sign of orderly thinking on his part. Only too often, in a laboratory particularly, they will crawl behind the defense you can't work unless things are all littered around. That to me is pretty much of an alibi. I rather feel if a man will keep his plant cleaned up he will keep his equilibrium.

Mr. Coburn: Mr. Larson, I approve of keeping a plant cleaned up.

Mr. C. D. Decker (Bryan, O.): If you cooperate with the Conservation Department I think you will get a lot of shrubbery for nothing.

Mr. D. E. Bloodgood (Indianapolis): I would like to have really a showing of hands of people who represent various plants throughout the country who do keep people out of their plants or who have kept people out of their plants since December 7th. I have been very interested in this meeting. I don't believe we have an idea who or how many are protecting their plants and how many are not. Do you suppose you could ask that question?

Chairman Larson: Yes, I think that would be very pertinent. We have all had differing opinions on this. In order to get some statistics let us put it this way. How many of you individuals or plants that you represent have closed your plants to visitors since the war emergency? Let's take it for 24 hours and then we will ask for daylight hours.

(11). All right, how many of you keep your plants open and permit visitors to come in during the daylight hours. (18)

QUESTION: Does that imply daylight and not night?

CHAIRMAN LARSON: I said during the daylight. Now how many of you are permitting visitors to come whenever they please, as we did before there was a war emergency? You made no changes from your former status. (12)

MR. BRYAN (Springfield, O.): I think this subject probably has dozens of variations that make it rather hard to make a clear statement by a showing of hands or a vote. In our plant, for instance, we have signs up and guards, our regular employees spend part of their time making the rounds. Other plants have guards that do nothing else, and still they let people come in. It is hard to get a definite statement or idea.

CHAIRMAN LARSON: I grant you that, but apparently there are two schools of thought and they are equally divided as to the necessity of taking these precautions. I don't know who is to say whether they are justified or not, but I am just a little surprised to hear Johnson say that the government stepped in in their case and made these regulations themselves. Has anyone else had that experience where the matter was taken out of their hands as to the decision and the government stepped in?

MR. RAWN (Los Angeles): That is on the Canadian borderline. That is probably the reason.

MR. JOHNSON: Our plant parallels one side of their canal. It is purely location.

A VOICE: In Alliance, Ohio, we were requested by the F.B.I. to close our water and sewage plants.

MR. NILES: In our particular case the coastguard demanded that we place signs saying "restricted area, keep away," and that we keep gates at the entrance to the plant. Of course, we don't require fencing because we are on an island in the river and all we have to do is put a gate across the bridge. That is Toledo. We do not maintain a guarded bridge. We have the gates open during the day, from 7:30 in the morning until 5:00 at night, but they are locked then until 7:00 in the morning.

SEWAGE PLANT MAINTENANCE IN WAR TIME: MAINTENANCE OF SEWERS

By ROY L. PHILLIPS

City Engineer, Meadville, Pa.

Good sewer maintenance starts with good design. This is certainly a trite statement and has been made by everybody who ever wrote or spoke on sewer maintenance. Such a statement and many others in this short paper are justified by the fact that repetition has always been an accepted teaching method and we can all profit by an occasional review. Too often we assume a universal knowledge of answers which are familiar to some of us and completely outside the experience of others. It is the hope of the writer that a brief review of some fundamentals will provoke the discussion which is the heart of such a meeting as this one.

Good design and construction are fundamental and when combined with an ideal site having good soil conditions and topography can produce a sewer system requiring little or no maintenance. Unfortunately we seldom have an ideal site and too often have had neither good design nor good construction. Sewers are not water tight nor root tight and are frequently laid on very flat grades or too shallow and as a result, basements having little drainage to the main sewer are flooded by a slight stoppage or surcharge. The problem eventually becomes localized in one or more flooded buildings and the Public Works Department is called.

Particular emphasis should be placed on the construction of house connections. They are a more prolific source of trouble than any other part of the sewer system. Careful inspection is the exception rather than the rule and any kind of line and grade as well as poor joints is frequently accepted. The writer has succeeded in writing into the local plumbing code a required inspection and approval by the City Engineer's office of the entire branch to the building wall in addition to the regular plumbing inspector's work. This is done primarily to get measurements to plot the entire branch and building front on sewer maps but also offers an opportunity to demand and get improved lateral construction. This complete information on laterals is not often found but is invaluable when trouble develops.

The political inspection responsible for so much of our inferior construction in the past with the inevitable maintenance problems which follow still hangs over in many places when house laterals are involved. The sewer maintenance personnel should lead the fight for the best possible construction on new sewers or branches. More operating experience by designers and inspectors of construction would cut the maintenance problems of the future. A too ready acceptance of a new product sometimes leads to trouble. In one case, over-enthusiasm over a new joint, used on several thousand feet of small pipe sewer in wet ground, has resulted in surcharging a lower lying small trunk line and resulted in a sufficient number of telephone calls on wet nights to break the sleep of the guilty party. The only complete answer to this problem is some reconstruction and in many cases this will greatly improve the service and sharply reduce maintenance costs. The maintenance department should be alert to reconstruction possibilities and not be bashful about making such suggestions in the places where they will do the most good.

The construction of additional manholes and other additional cleaning facilities will make short, easy jobs out of long drawn out, expensive ones. On combined sewers or storm drains the old problem of catch basins versus inlets is still with us. Catch basins are out of place on short sewers where adequate velocities for self cleaning are present while inlets are equally wrong on flat grade, sluggish lines where quantities of dirt may be admitted. In border-line cases, it is still cheaper and easier to remove dirt or sand from a catch basin than from a sewer or drainage line.

Most of us will always have plenty of places where we must tolerate periodic trouble, due to a combination of circumstances beyond our control. Lines will be surcharged, roots will grow, grease will accumulate and stoppages will occur. Quick relief must be furnished and an investigation as to cause should be made. On combined sewers, a variety of things may be blamed but on a separate sanitary system the trouble almost always originates in house branches. The outstanding exception is roots from street trees. Stoppages in six inch house branches are rodded out into main sewers and if this occurs near the dead-end of a small pipe main where there is a low flow, a stoppage in the main will soon be reported. This report is frequently made by the plumber or house owner responsible and it is desirable that this information reach the city authorities before a troublesome stoppage occurs.

A long experience in one city will teach an official a lot about his own sewer system and regular sources of trouble should be listed and put on a regular inspector's schedule. Root stoppages are usually repeaters and can be avoided by noting their frequency and scheduling root cutting jobs in advance of trouble. This practice, in the writer's city, has eliminated roots as a real source of trouble in old pipe sewers although the city is particularly proud of its street trees. This work is done with a drum and cable type of cleaner set over two manholes, dragging a cutting tool either way. An occasional inspection of catch basins and grease traps at garage washracks will prevent many stoppages from sand, dirt and grease carried over into pipe sewers. Certain troubles can be expected from certain districts but some things cannot be anticipated. When the investigation of a stoppage in a local sewer brings to light a ten foot deep manhole filled to the top with some family's winter accumulation of coal ashes, you lose some of your faith. A single paving brick or some other small obstruction, frequently makes the needed dam to start serious obstructions which may partly or entirely stop the flow. A resumption of flow after flushing is not sufficient evidence that the trouble is over. A disc or other object of slightly less diameter than the sewer should be passed through the line to clearly demonstrate its freedom from obstruction. This is too often not done but will pay dividends. Insistence on this practice will force a lazy or careless cleaning crew to do a complete job.

Emphasis on safety is important in sewer maintenance work. Badly rusted and weakened manhole steps have been responsible for so many accidents that some cities have abandoned them entirely and are using portable ladders. The presence of gas, either from sewage or other gases leaking into the sewers, is a constant menace in some communities. Smaller cities with good sewage velocities, delivering a fresh sewage to the outfall point, are not bothered with sewage gases but there is always the possibility of leakage from outside sources. A good life belt and a sufficient number of men on a job to quickly remove an injured man from a manhole is an indispensible part of sewer maintenance equipment. Within the past month, three men were overcome by gas in a manhole at a private treatment plant handling ordinary sanitary sewage and some trade waste from the plant. After the collapse of the first man, the others entered for rescue work and were overcome. Fortunately no deaths resulted. Ventilating blowers, gas testers and safety belts are not luxuries and will be popular in this plant in the future. It is difficult to convince men who have had no trouble in years of service that real danger exists. A trip to the sewage treatment plant and an explanation at the gas engine operating on sewage gas, will help to demonstrate the possibilities of trouble.

A great number of tools for sewer cleaning are available today and in many cases, can be used from street level. A piece of two inch pipe, bent to a fairly large radius at the lower end and reaching from a point just inside the sewer line to street level, will serve as a guide for a variety of rods. Ordinary plumbers tape rods can be operated in this manner and additional lengths added at the upper end as desired. Round rods, designed to be revolved in the sewer with a cutting tool on the end, can be controlled with this guide pipe. Such rods are turned either manually or by motor and are widely and successfully used for removing obstructions when a single opening is used. Jointed, floating wooden rods are still used and should be a part of the equipment of any maintenance department.

Some ingenious transportation devices for sewer maintenance equipment have been rigged up by various cities. A truck, completely equipped for sewer maintenance work, will save a great amount of time on service calls of this type. The larger cities often have them but they are not always well designed. Many smaller cities would find them profitable. Steel cables and ratchet drums on angle iron frames with various size cutting tools are usually carried on low slung trailers to facilitate loading and unloading. Wooden floats with a supply of chalk line and clothes line should be on hand to pull a steel cable through from manhole to manhole when root cutting is to be done. Rods are carried to get a line through when a float will not work. Many special problem tools have been worked out by practical sewer maintenance men who have repeatedly faced the same problems.

The most indispensable tool in the writer's equipment is a revolving brass fire hose nozzle, a supply of 2½-inch hose and a good city water pressure. This is well known equipment but still dependable. Inserted in the low end of a clogged sewer where roots are not involved and the clogging material can be flushed out, this nozzle will pull the hose into the pipe as progress is made and provides sufficient water to give a good flushing velocity in the sewer where small pipes are involved.

Causes of clogged sewers seem to be standard with tree roots in an undisputed first place and grease second. Such obstructions as sticks and brick provide their share of trouble. Cleaning costs vary so widely that they seem to mean nothing and are of little use for comparative purposes. There is considerable variation in the treatment of house lateral cleaning. In some cities, this is the responsibility of the property owner and the work is usually done by local plumbers while in others all cleaning is done by city forces and billed to the owner. Careful house branch construction, according to modern standards, providing adequate cleaning facilities and city cleaning is probably the ideal combination. This system would probably keep the city forces in better control of the entire sewer system.

Modern traffic has affected manhole, inlet and catch basin casting design. Older castings are frequently both noisy and unsafe. Replacement lids and grates have been strengthened with ribs or otherwise and various gasket materials are available to quiet rattling lids. Where possible, lids are fitted tighter with greater depth along the side of the frame to prevent rocking and lids and seats are machined. In particularly troublesome cases hot asphalt is poured around the rim of the lid.

In some cities special problems are faced due to disintegration of sewerage structures from acid wastes or other causes. These troubles result from lack of information at the time of construction, a wrong selection of materials or a changed sewage composition. Such conditions may arise in small or large sewers and involve patching, relaying, lining or other action dictated by local conditions and cannot be even briefly treated here.

One of the greatest maintenance problems is getting sufficient money appropriated to provide any real maintenance. No city service is more effectively hidden from the tax paying public than a sewer system. Sewer rentals sometimes solve this problem but this is frequently a backhanded and expensive way of getting money, for an indispensable utility. Other functions of city government are publicised and romanced, but although none are so necessary unless it is water supply, little is said about sewerage. Where an attractive treatment plant is present, a better opportunity for salesmanship to the public is provided. There is nothing wrong with a little showmanship and it is a weakness with technical men that they use so little of it.

Discussion of Paper by Roy L. Phillips

Mr. Horbin (Akron): The methods mentioned by Mr. Phillips are more or less universal throughout the country, but we have an outfall sewer problem that we haven't solved. It happens to be a rectangular section on a flat grade about 10 to 12 feet wide, 7 feet high and at the present time there is accumulated about 20 inches of silt. The line of this sewer has various angles to it and the manholes are constructed so far apart that there are not manholes at all the bends, so we are trying to find a method of cleaning the sewer without by-passing it. Furthermore, with the type of sewer laborers that we have, they will not enter a sewer to clean it and we have tried the silt scraper method, because we have one point at which there is a door large enough to admit a rowboat. That is located at a siphon chamber. That is the only access point on this sewer and we have tried to clean the one section in the hope that the rest of the silt would wash down to us, but that doesn't happen in all cases. We have lowered it a trifle after working about six weeks, despite the fact that there are times in the day when the flow gets so high that it interferes with the job, so we haven't been able to work a full eight-hour day.

There are other times, due to the synthetic rubber waste in the City of Akron, that shots of gas are given off and, of course, when they occur the men become frightened. It is not actually dangerous but they become frightened and won't work. When we try to work at this particular job we find we get about two full days in the week out of it, so our six weeks of work has not gotten us anywhere yet. I was just wondering if anybody had a similar problem and could give us a little tip as to how to remove this silt. We know by turning the sewage out into the river, by-passing it, we can remove the silt. Well and good, but we can't throw 40,000,000 gallons of sewage into the river. It would sort of hurt the conscience of our engineers.

Mr. Ramseier (Berkeley, Calif.): There was a method developed by Mr. Rawn in his district that I tried out myself on gravel, in a circular sewer 7½ feet in diameter. We put a meter in and found the gravel to be about 11 inches deep just above the meter and then it tapered off to nothing about 150 feet upstream. The gravel ranged in everything from peagravel up to building bricks. We took a piece of plywood, cut it to the shape of the sewer, only two feet wide so it was only a sector of the sewer, and put that into the sewer with a tail board on it and a couple of ropes to keep it straight. A couple of us walked up the sewer during low flow to above this gravel deposit and rode that down. Now the water running dammed up behind this two-foot board jetted out from under it, provided enough jet to move the gravel. We moved that whole 150 feet of gravel in one morning's work.

I have used the same principle in smaller sewers, the idea Mr. Rawn has developed with beach balls, and moved a lot of sand in a short time.

Mr. Horbin: This particular silt has a little quicksand with it and becomes so hard even in the water that it is almost like concrete, so it has to be stirred up. We should have some method of plowing to stir it up so we can move it. We have to move it because it is above the pump.

Mr. Niles: I wonder if this suggestion might not help. Put in a small type of dredge that you could float down—a modified type which would operate in, say 20 inches of water—if that is about the depth of the silt you have. It is done quite successfully in small drainage systems.

Mr. Enloe (Atlanta): We had a section between our bar screens and our grit collectors that is very wide and we had the same accumulation of silt which we removed by building a partition and running all the water through a part of it, down the center.

Chairman Larson: Who was it that cleaned out his stables by sending a river through?

A Voice: Hercules.

Mr. Brooks (Worcester, Mass.): Mr. Phillips has covered the whole situation, it seems to me, on the ideal way of maintaining a sewer system. I was glad that he brought out the fact that a sewer system is very little appreciated by the public as long as it is working, and to carry that still further, it is very little appreciated by the governing powers. Now you cannot maintain a sewer system in any city of any size—we have some 400 miles of sewers in Worcester—unless you have adequate funds. We take care of our sewer system in Worcester more or less on the hit or miss scheme, due entirely to the fact that we don't have sufficient appropriations to inspect and to take care of the lines as we should. If a breakage occurs, we take care of it. Our catch basins are clean as long as our money holds out, and so it goes. That is really a vital thing—to get sufficient money to take care of your works. Sewers once built should be properly designed and properly built, of course, but once built they are forgotten unless something happens.

Mr. Phillips spoke of catch basins and the necessity for trapping them, and I hold to the school that all silt should be kept out of a sewer. I don't care whether it has an outlet or not. I can't see any sense in admitting sand or grit into a sewer and letting it go to the outlet of your surface sewer and then show a let-up. Of course, in some sections you may have an outlet good enough so you can stand that, but we take advantage of all local existing waterways. We have to take care of the outlet or there will be shoals in the pond or brook. We go on the theory that we will remove the grit from the catch basin and prevent it from getting into the sewer itself. Roots and blockages of main sewers occur in any system. Great care must be taken, of course, on joints. Our system in Worcester started back in 1860, so we have a great many sewers that are hoary with age.

I was rather interested in Mr. Horbin's remarks about his outfall sewer and the silt in it. It strikes me that it is quite a problem, but I hold to the fact that a jet of water properly maintained will carry that along. We have had one or two cases in Worcester where we have had to get in and clean it by hand, but we weren't faced there with an excessive amount of water. Maintenance of sewers is a never-ending proposition. There have been some mechanical devices developed which are very satisfactory. A maintenance force that thoroughly understands the layout of your system is vital to property maintenance.

Mr. Rawn: Chairman Larson, this gentleman has asked a question right here that I think he ought to be answered on,—the matter of cleaning out his sewer. Mr. Ramseier explained it in part, the action of the jet to scour out and scour up underneath the volume of the flow and scour around the edges. What you do is to build something that just fairly fits your sewer, all except the top eight inches, weighted down with stones instead of Mr. Ramseier, and put a trail on the back so it won't obstruct the manhole. Let the water push that down freely. As it pushes it, the jet works the sand up to the top and carries it along and the more constricted the opening becomes on the top of the sand the faster the velocity is on the sand and the more it is carried along. If it is carried too fast it looks as though it will stop your trail line and it stops it when the flow is too high, but you can control it absolutely. You can scour anything out of that line that will move. I know you can do it constantly. We have miles and miles of sewers that have thousands of tons of sand in them that we have to dig out every year. That is the way we do it.

Mr. J. J. Woltmann (Bloomington, Ill.): The District of Bloomington had an experience two years ago. The interceptors were almost entirely built with wells. About three-quarters of a mile of that interceptor was three-quarters full of gravel and all of the jetting methods and other methods that were tried finally ended up with two of the Milwaukee cleaning machines. You are familiar with those. It is a windlass type operated with gas engines and it took two of them, one on each end of a section of sewer. The manholes were 400 to 500 ft. apart. In several cases where they were farther apart than that we had to break in the top of the sewer in order to make any speed at all.

Finally the man who was doing the work devised a scraper out of an ice machine can. You can imagine a section of a block of ice made into the shape of a scraper and by putting the windlass on each end of this section to drag it back and forth, keeping the men out of the sewer. We had the same difficulty. It wasn't dangerous but there wasn't much room to work in the sewer. One would take it back and one bring it out with the gravel. It was so shaped the gravel would come up to the top. There were 20 or 30 carloads of gravel.

Mr. Horbin: I believe you are talking about the Champion machine. We have that, too. In order to operate that properly, you ought to have a manhole or a hole in the center of the sewer. That we can't do unless we crack these three or four sections.

Mr. Woltmann: We did that thing. The bucket fit very well.

Mr. Horbin: We have no trouble with the circular section. There is a circular section upstream on this square or rectangular section in a low area. There is no coverage to it whatsoever.

Mr. Phillips: May I ask the gentleman, How long is that sewer? Don't you have any openings in it at all, that rectangular part?

Mr. Horbin: Just the manholes 600 feet apart. Those manholes are built on the side of the sewer and as I said, it has so many angles to it there isn't a manhole on every piece. You have to pull around the curve. Of course, you have to put a man inside the sewer to sort of guide this cable or it would wear out in a short time and we can't get the men to enter the sewer. We used to have men who would get into a sewer any time. They were fearless as far as sewage is concerned, even duck underneath the surface of the sewage, but you can't get those men now-a-days.

Mr. Phillips: I would like to comment. It seems to me it comes back to the start of my paper. It points out the great necessity of the men who have to operate these sewers watching the men who are going to design them.

While I am on my feet I would like to emphasize one other thing. I don't think the sewage man gets the proper recognition. It is hard to romance sewerage and do this sort of thing, not trying to sell yourself particularly. It is sort of a phobia with me that the Stetson hat day of the engineer is over, and too many men are saying, "I have to make speeches and write articles and get out in front of the woman's club and try to sell my sewer system." If I have to do that I will get into some other kind of a job, but I think a great many of our troubles hark back to that very reticence on our part.

I have felt the sewer rental situation, while absolutely necessary in many places to give us funds to take care of our sewer systems, is certainly an extravagant way of getting money, where we build up an enormous overhead to get a little money, particularly in large cities. If we would use half that effort in selling the sewer system and making the plants attractive as Mr. Cameron has told us, and get people to see the things we have, we could get the money by regular appropriation.

Mr. Horbin: I believe as Mr. Phillips does. I believe the glamor is in the design and construction of the sewers and possibly in the design and construction of the treatment plants, but there is no glamor in between those two points.

Another thing, I believe the designers should have a little training course in sewer maintenance before they do the designing.

Mr. Cook (Painesville): I would like to ask Mr. Phillips what his experience has been in using copper sulfate.

Mr. Phillips: For what purpose?

Mr. Cook: For the purpose of killing roots.

Mr. Phillips: I have had no experience personally. I have two or three friends who have tried it. One friend who used copper joints, which is supposed to do that job, and they have been rather dubious of the results. I think the copper will do the job if it gets to the right place at the right time. It is pretty difficult to get it to the right place at the right time.

Mr. Cook: I have tried that this summer and in places where I could see the roots before I have inserted the copper sulfate I have noticed that the roots did turn black and to my knowledge the roots haven't let go yet but it is my hope they will.

Mr. Horbin (Akron): Mr. Chairman, I read an article in *The American City* that in California they use copper sulfate.

In this article they could almost time the time when the roots reached the treatment plant. If that man is here, let him tell us about it.

Mr. Rawn: That sounds like Berl Phillips of San Diego. He has roots that would reach from here to the ceiling and completely fill up the sewers. I think they must have been very poorly constructed sewers in the first place, and in the second place, I don't know but what he saves the whole accumulation and puts them in one place. Berl might be able to tell you about copper sulfate.

We have used a lot of things. Our personal proclivity is that an ordinary rubber beach ball surrounded with a canvass will tear off almost any root that gets into the main line if the pipe is not broken, because the connection from the outside comes through an almost infinitely small crack and you get the power of the beach ball. It jerks it down and takes it downstream.

Mr. Larue (Akron): There is a question I would like to ask. What is the practice of cities generally with reference to testing for explosive gases in sewers?

Mr. Phillips: I am one of the gentlemen who has just come to life to the need for proper gas-testing apparatus. I am trying to get it as soon as I can. I know several places have had it and have seen several demonstrations. I am thoroughly sold on the need for proper gas-testing apparatus in a sewer system, not only for the gases you think you are going to find but some general apparatus because we have had several cases of leakage of natural gas in the sewer system. We are in a natural gas country and sometimes it will get in. This, incidentally, I am not free to give the details on, but it was not sewer gas, not the product of the digested sewage. It was leakage of industrial gases from a plant on the sewer system. I think it is quite necessary to make rather complete gas tests if we are going to do it at all.

Mr. Hommon (Canton): I wonder if the representative is here from Milwaukee. I happened to be up there a month ago. They made quite an extended study on sewer gas. As a matter of fact, I think in 1936 or 1937 they had a W.P.A. project which made an entire survey of the city and made analyses of the gases. When they go out into an area on any kind of a repair job, before they go they check to see if there is any kind of a dangerous gas there, and they have their ventilating equipment they take with them.

Something else that was interesting to me up there was on roots. They were taking roots out and using ordinary log chains. They would put one through and take part of it and gradually add on pieces chain to clean the roots out. I though that was rather interesting.

Mr. Larue: I am interested in what is the practice of cities. Do they make tests for explosive gases? What are the cities doing to prevent lawsuits for damages due to explosions and things of that nature.

Chairman Larson: I dare say all of us are more or less negligent in that regard. We realize the necessity, but we just don't take the necessary precautions.

Mr. Brooks (Worcester, Mass.): I can speak for my town and my city. We have all that equipment but I have the devil's own time to get my men to take it out when it is necessary. They have been working in sewers and when they lift off a manhole cover and take a whiff, down they go. I haven't had any trouble, but I have found the safety belt, with lamps and with gas-testing devices, are in my stockroom because they never take them out unless somebody is there and tells them to. As far as illuminating gas, when we get a complaint of gas in the sewer, we immediately turn that over to the gas company, and I will say this for the local gas company: they have all this equipment and they are testing all the time. Now I think my condition perhaps is true in many eastern cities. They have the equipment but don't use it.

Mr. Van Kleeck: Mr. Chairman, getting back to Connecticut again, I am sorry to say that of 40 major municipalities in Connecticut we have only one to my knowledge that uses safety equipment. I think that is unfortunate, not that we are having any great number of casualties, but that is the trouble with the sewer maintenance work. We only have isolated cases and then something happens and everybody gets busy and is safety-minded all of a sudden. However, they try to get a good standing with the Connecticut State Health Department by carrying the necessary equipment. I have in my car oxygen deficiency indicator, with an aspirator to test the gas in the sewer to see if there is sufficient oxygen and see if there is any hydrogen concentration or other high explosive gases. We also use carbon monoxide ampules to detect carbon monoxide.

Just last week I was checking on overflows. We found a gas leak of considerable proportions and reported it to the New Haven Gas-Light Company. I also carry a bottle of lead acetate and moisten filter paper with that and put that in the manhole for ten minutes or so to see if there is any concentration of hydrogen sulfide. There are one or two other things we carry also. We try to set the example. I wouldn't want to have anything happen when I was working on the sewer with a maintenance crew. There is a lack of attention to that problem as we all know.

Mr. Rawn: I want to cite an example of the City of Los Angeles which is out of my field. They have what they call a package delivery truck which has all the insignia on it to make it appear to be a dangerous institution. They are constantly going over their system and testing to see if there are explosive gases. The reason they do it is because they are constantly having explosions. Our whole colony up there is built on the basis of oil and gasoline and kerosene and their high oxidation, but these gasolines are all through the area and the sewage is actually full of gas from time to time. They take the most extraordinary pains to keep from having explosions. The thing we test for most is carbon dioxide and hydrogen sulfide. We had two men killed not over two months ago, one of the workers in one of our sewers. There are a large number of men killed in California and particularly in the metropolitan area because they didn't take precautions regarding hydrogen sulfide.

MR. LARUE (Akron): The basis of my question was this: Last December we had an explosion in one of our large storm sewers which killed three people and injured some 26 others, and as the result of that, damage suits amounting to probably half a million dollars. Well, of course, I am wondering whether it is the general practice of cities to try to test for those explosive gases or whether it is the general practice to wait until somebody reports it and then test.

OPERATORS' TURNTABLE

The Significance and Value of Laboratory Tests in Sewage Plant Operation *

LEADER: LEROY W. VAN KLEECK

Sr. San. Engineer, Connecticut State Dept. of Health

The meeting convened at 9:40 o'clock, President Bedell opening the session. Mr. LeRoy W. Van Kleeck took the chair.

CHAIRMAN VAN KLEECK: I note that the Program Committee is calling this a turntable, and I think that is significant because we want everyone here this morning to have a turn in these discussions.

Confidentially, I think everyone who conducts a symposium of this type has a fear of that dreadful moment when there is nothing but supreme silence. Somehow I am not worrying very much about that this morning after listening to Mr. Larson's symposium yesterday afternoon, in which the engineers seemed to have a great deal to say about plant operation. I don't think that the chemists this morning will maneuver themselves into the position of admitting they haven't anything to say on the same subject. I don't know how it is in the midwest but over in New England there has been (shall I say), a friendly feud between the engineers and the chemists for some years as to which is the more important. (Laughter.)

The subject today is the "Significance and Value of Laboratory Tests in Sewage Plant Operation." Limiting a full morning's discussion to a single topic is somewhat of an experiment in so far as Federation meetings are concerned. I know that it will, however, be successful. In addition to the topics that are listed on our program I hope that we will have a little time to discuss some of the miscellaneous tests, such as pH, volatile acids, volatile solids, gas analyses, and chlorine residual. There are a number of them if we have the time.

I, and I might add you, are fortunate in securing the help of some of our able associates in this Federation in opening the various subjects this morning. The first one on "Sampling and Preservation of Samples," will be introduced by Mr. Don Bloodgood of Indianapolis.

MR. BLOODGOOD: You said the chemists and engineers have been carrying on a friendly feud in New England. Far be it from being a friendly feud as far as we in the mid-west are concerned. (Pointing

* Operators' Symposium, Third Annual Convention of the Federation of Sewage Works Associations, Cleveland, Ohio, Oct. 24, 1942.

at Larson.) He is a friend of mine and I am a friend of his. He is a chemist and I am not.

In general, I believe most everybody thinks that sampling is a pretty simple thing, and yet every time I get a chance I say what a complicated and important thing sampling is. In fact, I try to impress upon the men in my organization that it is probably the most important thing in the whole laboratory procedure. It is pretty hard to tell a plant operator that he is more important than the chemist because he thinks you are lying or you ought to give him a raise.

But sampling is important. Why? Because it is so difficult to do.

For example, you can get into a long discussion about how long the sampling period should be: whether it should be one minute or one hour or two hours or one day or every three days or whatnot. To have really representative samples, I suppose we should take one small portion of the sewage out of every gallon that comes in, but it is impossible. You can't do it unless you have an automatic sampler, and have confidence in it.

In general, I think where you have large quantities, perhaps sampling once an hour is adequate to give you the information you need, and yet it may not be in your particular case.

How much sample should be taken? Should you have proportionate samples? I believe that you should.

How the sample is taken is very important. We have found in our sampling that it was almost impossible to check samples and so we started to work on whether we were taking the samples correctly. We were taking our samples out of a channel that was very turbulent. Yet, we found if you took the sample there you couldn't check with sampling in other places. So it was necessary to develop an aluminum tube with a stopper that could be jammed into the end. Then we lowered the aluminum tube into the channel and lifted it out. The stopper was removed and the sample dropped into a can. The can's contents were mixed and poured into a tube with a piston in the bottom. The piston had been set at such a point that it corresponded to the flow. The excess of sample spilled over the top. We have in this way been able to get samples which at least check. They are not higher in solids than looks reasonable, and we won't get samples coming from the secondary tanks that are stronger than the influent.

Then consider the preservation of samples. Immediately after collection, our samples are put into a composite bottle and placed in a refrigerator. We think it is absolutely necessary to refrigerate samples. The composite period ends at 8:00 A.M., because that gives the least possible time the composite sample can be held before the chemist starts to work on it. It is confusing sometimes to an operator to believe that his day ends at 8:00 o'clock on the day after the day of the sampling, but it is in our opinion worth while. I don't believe any sewage sample should be held longer than absolutely necessary before the chemist starts to work on it, that is, provided Mr. Larson, the chemist, can run it correctly after he gets it. (Laughter.)

I have run across people who have sampled their sewage three days a week. I have no complaint to make on that method of sampling. The complaint I would have to make is that the plant operator who has his samples taken in that way often says that his sewage is of the average strength of the samples he takes on Monday, Wednesday, and Friday, and I believe most of you will agree it is not a very average sample of the sewage coming to the sewage treatment works throughout the week. If he takes the results of Monday, Wednesday and Friday and says that these are the analyses of Monday, Wednesday and Friday, very well, but I think it is entirely wrong to say this is my average strength of sewage.

Have you enough, Mr. Larson, to start on?

Mr. Larson: You are out on a limb. (Laughter.)

Chairman Van Kleeck: Thank you, Mr. Bloodgood, for giving the chemists something to talk about.

Mr. Lanphear, what do you do at Worcester, Mass.? How often are the samples collected? What size dipper do you use?

Mr. Lanphear (Worcester, Mass.): Collection of plant samples is made in the following manner at Worcester: hourly portions of sewage, Imhoff tank effluent, trickling and final settling tank effluents are collected in 250 c.c. screw-cap wide-mouth bottles. The hours, P.M. hours with a circle about the figure, are painted on the caps in the four different colors; varnish is used to protect the painted figures.

The 24-hour daily composite samples are made from these hourly portions in the following manner: the rate of sewage flow for each hour as taken from the Venturi meter chart is recorded in a column in an inexpensive stiff-covered notebook. (Aside from use in sampling, this record is available for sewage flow studies.) A chart has been prepared which indicates the quantity of the hourly sample to measure into the composite sample. These quantities are recorded in a parallel column, using ditto or dash marks for like quantities. In this way, change of size of sample is plainly indicated.

M.G.D.	8–12	13–17	18–22	23–27	28–32	33–37	38–42	Flow
	10	15	20	25	30	35	40	
× 5 c.c.	50	75	100	125	150	175	200	High
× 7.5 c.c.	75	112.5	150	187.5	225			Medium
× 10 c.c.	100	150	200	250				Low

Copper dippers are used which hold exactly these quantities and resemble measuring cylinders with wide base and only a slight pouring indentation. The work of sampling is rapid when a funnel is used in the one-gallon bottle or jug.

The three factors are used according to the daily flow and are designed to provide sufficient quantity of daily composite samples with which to make the routine tests and the two sets of weekly composite samples.

Certain weekly tests require the making of total and filtered composite samples. The quantity of sample in cubic centimeters used is 10 times the 24-hours sewage flow in million gallons, to the nearest unit of 5 cubic centimeters (22.3 M.G. = 225 c.c.). Two sets of samples are prepared using sulfuric acid as sterilizer or preservative in one set and formaldehyde in the other.

Iron is determined in a set of monthly samples made by compositing one-fourth of each weekly composite preserved with formaldehyde.

I think that takes care of Worcester.

Chairman Van Kleeck: Thank you, Mr. Lanphear. Anyone else?

Dr. Mohlman (Chicago): There are two things to which I wish to limit myself. We are discussing the most difficult question first, the sampling, because it seems to me that most all the troubles, certainly in the larger plants, are traceable to the sampling technic rather than the technic after it gets into the laboratory. First, we have to consider all the miscellaneous details of two major methods of sampling,—automatic sampling and hand sampling.

In hand sampling you certainly have a time frequency limit. Individual samples are usually collected at hourly intervals and made into a daily composite, either with or without being proportioned according to flow.

In industrial waste work with hand sampling, we find that samples should be collected every fifteen minutes at least, maybe every ten minutes, and in proportion to flow, because a sample every hour is very unsuitable and will give you rather wide variations.

When sampling at sewage treatment plants, you have to decide whether a sample taken by hand every hour of larger volume and preserved is more accurate than a very small sample taken every two or three minutes from an automatic sampler; I don't know that anybody has the answer to that. The automatic sampler has the advantage of frequency of sampling, but it has to take a smaller volume, and these automatic samplers have to be watched very carefully because they will fill up with slime and growths and it is quite a problem to keep them in working order.

Next is the question of preservation of samples. Now there is no doubt that samples should be kept as cold as possible. The question is how conveniently can that be done. With hand sampling the individual samples should be placed in a refrigerator or cold box of some sort immediately and then a composite made up after a day's set of samples has been preserved at that low temperature. With automatic sampling it isn't so easy and since we have automatic samplers, I was interested in seeing what preservation meant, that is, whether it is essential to have the samples immediately cooled.

Dr. Hatfield's Standard Methods Committee reported that as much as 40 per cent decrease in B.O.D. had occurred in some particular samples that he had, that had not been iced. That rather astonished me, because that is a tremendous change. And, on the other hand, Dr. Rudolfs had reported, quoted in Mr. Keefer's book on page 487, they had a very great increase in B.O.D. in 24 hours. The increase was from 165 to 238 parts per million, standing at room temperature.

We ran some comparative tests in which the individual hourly samples were iced, and our difference (decrease) was only about 3 to 5 per cent on quite a series of samples. I don't think we should fear that we would get a 40 per cent decrease such as Dr. Hatfield reported, for it seemed to me it might have relation to the temperature of his sewage, which averages 100 F. in summer as compared with the average of 73 of some 20 cities quoted by Keefer on page 69, and 72 F. in winter compared with an average of 51. So, of course, if you have a warm sewage or warm industrial waste, there can be a very rapid change in the B.O.D. and if we could get electric refrigeration and handle these automatic samples, keep them a little colder, I would be pleased to do it, but I don't believe the errors are serious or of very great concern.

Now, however, you have to keep in mind that in sampling raw sewage there is a question of whether an hourly sample by hand is so infrequent that you may have variations in between that will be caught better by the automatic sampler which takes a sample every two or three minutes.

There is another factor: with a high B.O.D. a little aeration or warming up of the sample will not have so much influence as it will have when you are sampling a polluted river, for example, where your B.O.D. probably will run from 10 to 50 p.p.m. Then it is absolutely essential that you ice the samples and prevent any change in the B.O.D. during the period of storage.

I am afraid we can never get through talking about sampling. Sampling is a serious problem for the chemists and engineers in large plants and it just seems to be a problem that is never solved, as to the best place to take the sample and the technic, so you have to make the best of a rather difficult situation. I don't know of anything that is as difficult to sample as sewage. Coal is comparatively easy in comparison. So you certainly have a tough problem to discuss here and any light on it or suggestions are welcomed by all of us I am sure.

Dr. Symons (Buffalo): You mentioned temperature variations. How about other characteristics?

Dr. Mohlman: Of course, the more putrescible a sample is, the more rapidly you can expect a change in the sewage. If it is a weak sample it will react more slowly.

Mr. Sloan (Wisconsin): I wonder if any operators of smaller plants have tried setting up continuous samples, particularly on the raw sewage as an indication of the sampling period required in their particular plant.

Dr. Mohlman: I think that is more a question for the chair to put than for me to answer.

Dr. Hatfield (Decatur, Ill.): I think I can defend myself. (Laughter.) In regard to this temperature of sampling, I happened to get into that line of work because we built an automatic sampler that would collect a small sample about every minute, set it in our raw sewage, and compared analyses with those of our hourly samples, over a period of about nine months. We were rather surprised to find under our particular set-up at that time that we had almost a constant 10 per cent difference in our samples. That is, our regular hand-collected sample was 10 per cent higher. That looked queer. If it were due to industrial waste or irregularities you would expect your automatic sampler maybe to be 10 per cent higher one day and 10 per cent lower another day, but the difference was very constant. Well, that particular work was started in the spring and passed through the summer, but as the winter period came on results were closer together. So then we set out to see what was the effect of temperature. We collected grab samples and immediately determined the B.O.D. and immediately chilled them. We found we just couldn't take a bottle and set it in the incubator or cooled water and expect it to cool quickly enough. If you want to catch the B.O.D. quickly enough, you must use some ice to cool your sample. We found that our percentage drop in B.O.D. was pretty much in proportion to the temperature. That is, if we kept our temperatures at 4 F. we could hold the B.O.D. in pretty good shape. If it was 20 degrees, we had a 20 per cent drop. If the sample was kept at 30 degrees we had a 30 degree drop. I thought that was probably due to our particular type of starch waste. So we went out and sampled the sewage where the starch waste was coming into the sewers and then some of the ordinary domestic sewage. We found the results also dropped there, speaking in terms of the 20 and 30 degree samples.

So I was convinced it was not the starch waste. Soon after I reported that work, Kraus of Peoria became interested and he did the same work, and the surprising thing was that where I was getting 20 and 30 and 35 per cent drop (I think the 40 per cent, Dr. Mohlman, is really Kraus), he got 40 and 50 per cent drop. In other words, he got a whole lot more decrease by not preserving samples than I would get in our primary treatment tanks, so Kraus went me one better and collected individual samples and sealed them with stoppers. That is he kept them away from the air, which makes a difference of another 5 or 10 per cent. Now we get to the condition that Dr. Mohlman reported. I have had the same report from Dr. Edwards in New York City, that he gets only a 10 per cent, or small drop there.

I am inclined to think that in the large cities with large intercepting sewers, and probably a considerable time lapse, the drop has taken place before the sewage arrives at the plant. When you come to the smaller plants where there is only an hour or two hours or two and a half hours as we figure at Decatur, we get a fresher sewage and the B.O.D. that is so rapidly oxidized gets down to the smaller plants more quickly.

There again it is a practical proposition, as Dr. Mohlman says. What is it we are trying to determine? But I do know that the B.O.D. will drop in a domestic sewage very rapidly. Dr. Rudolfs reported an increase in B.O.D. From my reading of the article and the rest of the analyses, I think that was due to hydrogen sulfide. Apparently the water was a sulfate water or waste and the sulfates were changed over to hydrogen sulfide and naturally on incubation you would have a B.O.D. or a sulfide demand which increased as the sewage decomposed.

That is my defense for maintaining the low temperature and I would be interested in how many others have checked on that and how many have found the same thing. Apparently Bloodgood is sold on the need of low temperature. Did you do any checking, Bloodgood, to check my rapid drops?

Mr Bloodgood: We never could check the automatic sample with the hand sample.

Dr. Hatfield: As far as the hand sampling is concerned, I think we have a fairly good scheme. We do not collect proportional samples because our industrial waste discharges and our sewage flows are so close, and that is another thing we checked with the automatic sampler. I told you there was 10 per cent loss due to temperature. The automatic sampler checked within that figure of the hand sampling. However, our flows do not vary more than 20 per cent, so with such a constant flow it is not so necessary for us to take sample proportional to the flow.

On our sampling, however, we do feel that you should get a sample as near the cross-section as you can. Now we didn't make the type of tube arrangement that Bloodgood has, but we use a four-ounce screw-cap bottle. We drill a half-inch hole in the cap, put a little tube in it and when you sink that into the sewage, the air starts bubbling out and the sewage flows in. We have only four feet of water in our conduit and the sampling man can put the bottle down to the bottom, lift it up, put it down to the bottom and lift it up, and make about three of those dives to the bottom. In other words, he puts it down and brings it up in about three different places in the conduit so he gets an average sample.

I haven't a lot of analyses to prove that is absolutely correct, but it seems a logical way to collect a sample through a conduit and an easy way without any complicated mechanism.

Mr. Cohn (Schenectady): What is the diameter of the tube?

Dr. Hatfield: You remember I said a half-inch. Of course you are concerned about the size of the particles in your raw sewage. For effluents diameter of the tube is not so important. If you want to have time enough to make three of these dives you have to have your sampling bottle large enough or the tube small enough so it slows up the filling of the bottle.

Chairman Van Kleeck: Thank you, Dr. Hatfield. As I predicted, the chemists are talking all right. We still have five topics, plus all the miscellaneous tests we would like to consider.

The next topic is the B.O.D. test and dissolved oxygen. That will be opened by Dr. Clair N. Sawyer, now of Madison, Wisconsin.

Dr. Sawyer: I feel that most of you are more or less familiar with the technic of the ordinary B.O.D. determination and the applications which we can make of such a test. I thought I would discuss the question of improving the test. I expect many of you feel that we have arrived at such a state of perfection that we can sit back and determine B.O.D. without much thought or consideration of the material upon which we are working.

Many of you have industrial waste problems and they are the ones that give us the greatest difficulty. Domestic sewage has been pretty well thrashed over here and with all the variations that have been brought up, you can see that very careful analysis on the part of the chemist in the laboratory, who doesn't have control of these variables which have been discussed so far, may not be warranted.

The standardization of the B.O.D. test through the recent work of Mr. Ruchhoft and his committee I think is pretty well accepted at the present time. Most of us have been very happy to learn that we can utilize these new fortified waters on domestic sewages without changing the results which we ordinarily got with bicarbonate water or phosphate buffered water.

The question I would like to raise this morning is: What test do you apply to determine the quality of the dilution water used for the B.O.D. determination? To begin with we have to consider the quality of the distilled water. We have to take into consideration what we are adding to that distilled water. If it is a good distilled water, can we spoil it by adding our nutrient minerals? Are the nutrient minerals, the chemical compounds which we add to it, of such purity that they do not add any toxic materials, and so forth?

We have had for the past few years, thanks to Dr. Hatfield, a method whereby we could check on our results. In a publication way back in 1932 I believe he indicated he used a method whereby setting up different dilutions, if those different dilutions did not check within I believe 5 per cent of the mean value obtained on the different dilutions, he considered there was something wrong, probably with the dilution water.

In some recent work which I did while at New York University, I was working with pure substances to a great extent, with glucose in particular, and was obtaining very nice checks on the different dilutions which I would set up, but the B.O.D. which I obtained in five days' time was quite low, I thought, being only about 50 per cent of the calculated theoretical total demand. Other workers in the field have indicated higher values. I think Lea at Wisconsin had found values in the neighborhood of 62 per cent, and I think that work was checked by Martin at Green Bay.

I was quite concerned about these low values I was obtaining and still, according to Dr. Hatfield's method of checking, I was all right. My results of checking were sometimes within 1 or 2 per cent of the the mean value which I obtained on all dilutions.

This difficulty we tried to trace to the glucose. We checked, using glucose obtained from three different sources, and I would always come out with the same results. So I made up my mind there must be something basically wrong in the dilution water with which I was working.

I decided to set out and in the back of my mind had the idea of developing a primary standard. You all know we never have had a primary standard for our work in B.O.D. and anyone who has had basic training in chemistry in quantitative chemistry knows that is one of the fundamentals; knows you must have a basic standard to which you can relate your results. So we have been working on this basic standard or primary standard a little bit.

I made up some samples and five different solutions of pure substances. I started with three materials, made combinations of two of them, put them in ampules and sterilized them, and then submitted them to two different laboratories for analyses. I was very much surprised when the first results came back. The man who did the work was astonished at the close check results he obtained on different dilutions. We put up three dilutions of each of these samples. I had held back my results until I had received his, and then I sent him my results, and I think he was as much astonished to find the close check I had, but still there was about a 20 per cent difference between his results and mine. His were about 20 per cent higher. Well, that sort of confirmed in my mind that we had a local problem.

When the results from the other laboratories came in, I was still more convinced of it because the other results were also about 20 per cent higher than mine and as you might expect, they checked the results from the first laboratory fairly well.

We are hoping to be able to continue this work. It is my firm conviction that if we can obtain a primary standard which can be obtained from some supply house, if it could be made up from some simple substance which is obtainable in a purer form right in your own grocery, so to speak, it would be a great advantage.

In this work I think we should give considerable thought to seeding. We have had a paper very recently by Dr. Heukelekian from New Jersey on nitrification. It points out very definitely that we can become misled if we are not careful of our seeding.

Just one word on the determination of dissolved oxygen. I am afraid in many cases we are prone to add sodium azide and go ahead and run all of our D.O. tests with the use of azide. I don't believe that it should be used that way. I think quite often we can be misled in our B.O.D., especially if nitrification is taking place. If you are using the azide modification you may be, of course, getting a false five-day B.O.D., that is, false compared to what we would like to get.

Mr. F. Woodbury Jones (Cleveland): I never did feel I was an authority on B.O.D. nor do I claim to be one now, but I wonder sometimes if we don't strain at a gnat and swallow the camel.

I enjoyed this dissertation on B.O.D. and I wonder if a 20 per cent result might sometimes be 7.8 instead of 7.6 or something like that. I am thinking now particularly of the small operator. I believe we should train our men to have some knowledge of what they are doing, and some means in the laboratory of determining whether they have accomplished that which they are seeking, and so it occurs to me that in the small plant, particularly, it doesn't really make much difference whether the B.O.D. obtained from the raw sewage today is 150 or 120. But I do think it makes a great deal of difference in a man's conception of what he is doing if he gets varying results and then gets all confused.

If he finds that his effluent is indicated somewhere between 5 and 25, particularly if 25 is satisfactory, I think he has a definite vision. What I am trying to say is, I believe in each plant you want to get the relationship between the raw sewage and the final effluent and I doubt if it makes much difference whether you use a trick stopper or an old-fashioned stopper, whether you use an ice box or a pan of water. For any particular plant I don't think the relationship will change. However, if it is a question of a research problem, something else must be taken into consideration.

Going back to the sampling, all of this B.O.D. struggle doesn't mean much unless we have a good sample to work on. I think, too, that we lay too much stress on trying to determine the B.O.D. reductions when a man that has been around a sewage plant very long can tell by just looking at it, whether he is getting something worth while or not. I don't think he needs any B.O.D. test if he looks at the effluent from a certain plant to tell whether that plant is doing a good job or not, but I think as a matter of record it should be obtained. I think, too, solids are more important. I have had a lot of fun with B.O.D.'s all my life. I ran into a new one this year. I haven't traced it down yet, but I found that we were burning sewage gas in the laboratory and for some reason or other the ventilating fans weren't working and there was a lot of SO_2 developed in the atmosphere and some of that got in some of the dilution water, so you can readily imagine what that did to the sodium bicarbonate. There were some B.O.D. results that couldn't be explained in normal procedures.

So you see there are a lot of things that enter into this laboratory business and I do think that we would be much better off if we paid strict attention sometimes not to getting out a large volume of work but taking a little time off to see whether the type of work we have done stands up under a critical eye. The older I get, the more I wonder just how much some of our laboratory reports are worth.

Chairman Van Kleeck: Dr. Symons, what do you feel is the significance of the B.O.D. test at Buffalo? What prompts the question is the remark Mr. Jones has made about feeling the solids determination is the more important.

Dr. Symons (Buffalo): As you know, when Mr. Ruchhoft had his Committee studying B.O.D. a year or so ago, he wrote around the country and he asked me among others if we would undertake that part of the study. I wrote back and said, "I am not interested. Our problem has nothing to do with B.O.D." The plant was built for the purpose of removing bacterial pollution from the Niagara River primarily, only secondarily removing solids, and in the Niagara River, even before sewage treatment was practiced, the D.O. dropped only 0.3 p.p.m. from the head of the river to three miles down and the B.O.D. was only 0.7

p.p.m. It depends entirely on the plant. Even solids aren't as important to us as are bacteria. Does that answer your question?

Chairman Van Kleeck: Yes, it does, Doctor. I just wanted to bring out the point that some plants feel there are other determinations of more importance.

Mr. Ruchhoft (Cincinnati): Dr. Sawyer mentioned the fact that many of the people are dependent upon sodium azide. They have gotten so used to it they felt lost without it. I think all of us should get out of that state. There are a number of procedures that are available and even though azide seems the best at the time, that isn't the only one that can be used. We could go back to the Rideal-Stewart method and get along very well. In the absence of azide, I would suggest that we get familiar with sulfamic acid, which doesn't have the difficulties of the Rideal-Stewart procedure.

Chairman Van Kleeck: I use in the field the Isaac Method. The closest you can read the results is a half part per million of dissolved oxygen. Mr. Gilcreas wrote an article on the procedure about two years ago. It is a very convenient test for the small plant operator to use, because it only involves comparing a color which you get with amidol and sodium citrate with color standards which I find have been very permanent. I have a set of standards that was recently checked as O.K. by our laboratories that I have had now for three years.

I can allow a minute or two more discussion on this subject.

Mr. Calkins (Toledo): This B.O.D. dilution water is quite important to us because we have a very unusual waste coming into the Toledo plant. The Toledo plant has just primary treatment. This particular waste of about 10,000 gallons per day has a B.O.D., believe it or not, which runs from 400,000 to 750,000 p.p.m., entirely soluble. Iron solids and lime do not precipitate. In fact, B.O.D. is increased about 10 per cent when you raise the pH above 7, but we found in order to set up B.O.D. when this waste was in our sewers that we had to make infinite dilutions. Now this is sewage containing this waste in a ratio of about 10,000 to 36,000,000. You can break it down. We used one c.c. of this sewage in a litre of seeded B.O.D. water, and started with a tenth of a c.c. of that in our sample for B.O.D. tests. With bicarbonate water we got sliding scale results which didn't show us a thing, so I read in the *Journal* about Formula C water and some of the other waters, and Mr. Scott of the State Department of Health and I used a C water along with a bicarbonate water, a fortified water which was identical with the C water, with the exception of the 300 parts per million of bicarbonate, and we were at last able to get results which didn't have a sliding scale and they seemed to come out very consistent.

However, with ordinary B.O.D. water we just couldn't get any analyses on that waste that would show anything, because they would start at a million and come down to zero. Of course, it does things to our D.O. We have around 50 parts per million nitrite sometimes in our primary effluent because it contains a lot of amino oxygen and it is easily oxidized. We know there is practically no D.O. there. We know sometimes to make results come out the way we feel they should or just playing around with it, we used an azide method and then checked with Rideal-Stewart, and sometimes we use the Rideal-Stewart and then azide together, which may or may not mean anything.

We have a lot of trouble with that waste. Incidentally, azide can be purchased from Eastman Kodak Company. However, it requires an explosives license.

Chairman Van Kleeck: I am sorry to close the discussion. Apparently we should have limited this morning to just one test rather than laboratory tests.

The next topic, "Settleable Solids and Suspended Solids," will be opened by Dr. Fischer.

Dr. Fischer (The Dorr Co.): Mr. Van Kleeck, when he wrote me, suggested that I give five minutes to this topic and I am going to take him literally.

Suspended solid tests are probably run in every sewage treatment plant, and in connection with clarification tests that we have done, we feel that that is the most important test. When we get into the actual mechanics of the test we often wonder whether the suspended solids test means anything, and the reason is that we have found that in some cases we get a considerable change due to storage of samples.

One particular example that comes to mind was Coney Island where the tests on the clarifiers showed that results were rather poor. The tests were based on 24-hour composites, but when we analyzed the situation and started taking hourly samples, analyzing each hourly sample and averaging the results on each sample, we found the removals were considerably higher.

Now in some cases in some plants we have found that it didn't make much difference, so apparently it is a function of the type of sewage.

As far as the actual test is concerned, the Gooch Crucible Method is used by practically everybody, but I was rather startled a short while ago when on the west coast. When we started the test on Terminal Island, where they have a lot of fish waste, the operator told me I might as well forget that method because it wouldn't work on their sewage. Furthermore, he stated the aluminum dish method was not applicable unless you filtered the sewage. It was absolutely necessary to filter the material if that procedure were used.

Now on the settleable solids test, I don't think a whole lot of the Imhoff cone method because of the inaccuracy existing in that method, but the gravimetric method of running settleable solids has been used more and more and it apparently gives a very good check on the efficiency of clarification. I know Mr. Cameron—and I believe he is here—told me he has actually been using that method for six years and he said he is just about to drop it because it just appears on the records and you can't do much about it. Well, for the plant at Jackson I believe I agree with him that plant is working so perfectly I don't believe he can improve it very much.

In some cases you will find that the suspended solids removal in your plant may be 40 per cent and if you run a settleable solids test in the laboratory, you will find out in the laboratory you can probably get 75 per cent removal. That doesn't mean you can do the same thing in the plant, but it indicates some improvements might be in order.

I believe Walter Sperry did a nice piece of work along that line. He found out his removals were somewhat in the neighborhood of 40 to 45 per cent, and by studying these laboratory tests he found out he could increase the performance of his clarifiers by satisfactory baffling.

Now another interesting point in that connection is that if you take the plant results of removals and divide them by your laboratory removals, I use that figure and call it plant efficiency. Now in some work that we have been doing at Elmhurst, Illinois, a short time ago, we found out the plant efficiency figures couldn't be correlated with other data such as detention periods, so we took ratios of suspended solids, of residual suspended solids, or in other words, the suspended solids in the clarifier effluent and divided that by the suspended solids in the laboratory sedimentation and we got a good correlation.

The value of the laboratory tests on settleable solids and suspended solids is that there might be a method worked out for comparing clarifiers at different plants. Unfortunately, we have no method of making such comparison at the present time. Actual suspended solids removals mean little or nothing unless you know all the other factors connected with the sewage, but I believe that there is a tentative method set up in the new Standard Methods wherein certain sized vessels are recommended for laboratory tests and certain detention periods, and I believe if that method were developed and used in a sufficient number of laboratories it would be found a very good method of comparing clarifier efficiencies.

Chairman Van Kleeck: Thank you, Doctor. The question is open for discussion.

Mr. Schaetzle (Akron): I would like to ask Dr. Fischer a question. He says he finds results change by storage. I wonder if Dr. Fischer means storing in excess of 24 hours. In other words, 24 hours after the 24 hours.

Dr. Fischer: We found there was considerable change even in the 24 hour composite. As a matter of fact, after we kept some of the samples more than six hours there was a change. That does not happen in all samples. As a matter of fact, I can show you some reports where they show a change and others where they don't. You can get autoflocculation of sewage due to storage and that flocculation may be and often is different in your raw sewage sample and in your effluent. A different concentration of solids in each sample.

Mr. Schaetzle: I meant what is the remedy? Practically no plant can take the time to run hourly samples.

Dr. Fischer: I don't think there is any remedy.

Dr. Hatfield: I just wanted to add a word in regard to preservation of sample, of keeping your sample cold. It doesn't mean the solids may go up or go down over the 24 hours. That preservation has to do with the B.O.D. and I think, like Dr. Fischer, that you have to take it. We have had times when we got a shot of industrial waste. We would make our tests, and then keep the sample at 40 degrees. The suspended matter went up from 200 to 500 p.p.m. in 24 hours' time. So that isn't normal. Our normal sewage increases maybe 25 or 30 p.p.m. There is a flocculation of certain materials on certain types of sewage on standing and reducing the temperature does not help you.

Mr. McGuire (Columbus): My contribution may be rather elementary to this discussion, but it happens in the State of Ohio several of us do supervision work and I am oldfashioned enough to think the best way to find out what a plant is doing is to test the samples, and when there is no laboratory, I carry samples in to the laboratory and run those tests. It is always impossible to load a set of samples in the carrying kit, follow them 50 or 60 miles and have a settleable solids determination coming anywhere near to the settleable solids test run at the plant, and I am satisfied in my own weak mind that the matter of flocculation that takes place is because of the vibration which it gets. I drive an automobile of a kind, and I think it is that vibration of that storage period which causes the flocculation. I am satisfied in my mind it takes place in every sample we haul home.

Chairman Van Kleeck: We have had the same trouble in Connecticut. A lot of plants running the settleable solids tests have obtained much better results than our laboratories do on the 24-hour old samples that we bring in. We collect samples for six to eight hours at fifteen-minute intervals. From the time we take the samples until they reach our laboratory some of the colloidal solids are precipitated and our report is much higher on the settleable solids content than the plant operator gets, particularly on effluent samples. We thought of dropping the test for that reason but we still feel it gives us one indication of the efficiency of the plant. We, of course, run the other common determinations also.

Is there anyone else who would like to speak just a moment on this before we go to the next subject?

Mr. Coburn (Boston): On this question of suspended solids, it goes right back to the question of sampling again and your error is greater than your error in the determination of the suspended solids. The real measure of the determination is what are you going to do with the results after you get them. If there is a sludge balance or something like that, we will let Dr. Symons take care of it. If it is just to determine the way your plant is being operated from an operating standpoint, if you do get this after-precipitation of colloids and day by day it is a relative value, you can tell the efficiency of your plant from your own records. If it is from an academic standpoint, well that is an entirely different problem.

Mr. Larson (Springfield, Ill.): I am not going to talk about B.O.D. so you can let it ride over into the next period if you will. I have been sitting here listening very assiduously and trying to visualize what may be the small plant operator's reaction or that of the fellows who are starting into this game, from this maceration of the Standard Methods we seem to be going through. Poor old Standard Methods I think needs a defender, and I think we should have just a note of caution.

I remember Calvert wrote me a letter once from Indianapolis in which he made a statement I have never forgotten. He said "I am unalterably opposed to any effort to sample raw sewage." He ran into this sort of thing and apparently had thrown up his hands, and I suspect that a lot of the individuals that I just referred to are about to throw up their hands when they hear us tearing things apart.

We can't agree, ourselves, two weeks running, but after all, I think that we have got to hang together or hang separately on this thing and inasmuch as Standard Methods represents years of study and thought, we have got to stay with them until we find something better. We have a lot of laws on our books that are admittedly bad but if we are going to live in organized society and get along with our fellowmen we have to abide by them until we find something better. Of course, there are certain individuals we don't care about getting along with. (Laughter.) I don't want to get personal but if there is any doubt in your minds, I am referring to the engineers, of course. (Laughter.) It is fine to make investigations and try to improve them, but I still am a firm believer in holding to our Standard Methods.

Mr. Jones, of course, goes to almost the opposite extreme when he says all he has to do is to look at the effluent to decide. I think the longer we work in sewage the more we get that way. We make our test and compile them for statistical reasons but I suspect a great many of us run our plants by looking at the effluent. I think someone should defend Standard Methods.

It would be gross ignorance on my part to discourage any attempts to improve our methods but I merely wish to sound a note of warning that until we have agreed upon improved methods we must stand by the law as it has been developed through the years and recorded in Standard Methods.

Hatfield has worked so long at it that we have come to call him "Standard Methods Hatfield," and it is a thankless job. I am glad we have someone who is willing to struggle with it, but we still should have some faith in our own methods and if we can improve them, fine.

CHAIRMAN VAN KLEECK: Our next subject is "Relative Stability," discussed by Mr. Sanderson of Albany.

MR. SANDERSON (Albany): The relative stability test is one about which little is said at meetings such as this, but probably the plants that are operated or controlled by the relative stability test and the Imhoff cone test far outnumber those that are controlled by the more adequate laboratory determinations.

Standard Methods says to add 1.5 milliliters of methylene blue solution to the bottle and incubate at room temperature. In most of the laboratory tests that is done, although the 1.5 milliliters aren't measured accurately. The last Standard Methods changed the dye to zinc salt from the hydrochloride, and we had complaints from some of the engineers that the results weren't comparable. We made a few tests and one thing we did was to determine the dye content of the two samples. We found that the dye content of the methylene blue chloride was 90 per cent and the dye content of the zinc salt was 75 per cent. The directions for making up the solution were exactly the same, so the dye content of the sample was increased 17 per cent, increasing from 1.0 to 1.7 parts per million. That made a difference in the result because the dye is bactericidal and if the time that the sample decolorizes is greater than 5 or 6 days the time interval is increased a great deal because of the approach of the curve to complete depletion of the available oxygen.

We found in some cases where the sample was depleted of available oxygen that the dye prevented that depletion for a period of five days. Sometimes it was even longer.

That work was stopped due to other work coming up in the laboratory and we didn't pick it up again for almost a year. I used the same solution again and didn't check my results. It seemed the bactericidal effect of the dye solution had been greatly decreased in standing for a period of a year, so I looked up some of the literature and I found that the water solution of methylene blue is very unstable.

That is as far as we have got with it. We intend to go a little further and find out which of the dyes have bactericidal effect and which do not.

Chairman Van Kleeck: Gentlemen, I am very sorry to say we can't have any discussion of Mr. Sanderson's remarks on the relative stability test. We had planned to have Dr. Symons make a few remarks on grease determinations and Dr. Hatfield was to talk on the use and care of laboratory equipment. Apparently there is a great deal to be said about these laboratory tests and perhaps at some future convention we can continue our discussion.

Editorial

REGIONAL SEWAGE TREATMENT

The British Institute of Sewage Purification has recently submitted a memorandum to the Minister of Works and Planning, the Minister of Health, and the Minister of Agriculture and Fisheries, concerning reorganization of sewage disposal services in post-war reconstruction. The most important recommendation in this memorandum was that the planning, construction and operation of sewage treatment works be regionalized, and that the township should cease to be the unit of area for the administrative control of such works, but that the unit should preferably be the natural drainage or catchment area of a river, or of a tributary in the case of major rivers.

Regionalization is considered to mean the direction of a number of works within this river basin by a single administrative control, and not necessarily to involve centralization, or the creation of one or more large works to take the place of many smaller works.

In the past, the good work of one authority has sometimes been discounted by the action of a neighboring authority which discharges insufficiently treated sewage into the same stream. Regional administrative control would in time eliminate this inconsistency.

Discharge of untreated industrial waste has frequently counteracted the efforts of municipal authorities to abate stream pollution, and it was to correct this anomaly that the Trade Waste Law of 1937 was passed. The regional authority should have power to prescribe the conditions under which trade effluents are discharged into the public sewers, subject however to final decision by the Ministry of Health as provided in the 1937 Law.

The most radical step in these recommendations was that "regional authorities should be charged with the design, construction and operation of all publicly owned works," as this would give such boards the authority to establish a staff of engineers who would design the treatment works, as well as build and run them.

There is practically no precedent in England for handing over to regional boards the design of sewage treatment works, and very little precedent in other countries for this procedure. In the U. S., the Sanitary District of Chicago is an example of regional control of design, construction and operation of large works, also possibly there are several examples in New Jersey, but no others covering considerable areas come to mind. In Illinois, under the Sanitary District Law of 1917, a number of sanitary districts have been established, but in practically all cases they comprise only one city, and not all cities in a river basin.

In Germany there are a number of rivers boards which appear to have exactly the functions proposed for the post-war regional boards in England, the best known being the Ruhr and Emscher Boards.

Most river conservancy boards in England, such as the West Riding of Yorkshire Board, do not design, construct or operate sewage treatment works in their area, but exercise supervision only by inspection and friendly coercion, when necessary. In the proposed new scheme, the regional authorities would still be responsible to the local river conservancy authority, and the latter presumably to the Ministry of Health.

There may be considerable similarity between this proposed innovation and the river conservancy boards proposed several years ago in the U. S. by the National Resources Committee, whose first project, the Potomac River Valley, almost reached establishment, but failed for lack of funds. This project was different from the British scheme, however, because the U. S. Government was to provide the funds, whereas in the British setup the local communities would assume the costs.

There are many good reasons in favor of the British proposal, some of which have been mentioned. Others are that the regional authority would be able to draw up a long-term program, would have closer cooperation between designer and operator than now obtains, would operate small plants better than they are now operated, would unify practice and charges for treatment of trade wastes, would promote utilization of sludge in agriculture, and could plan and carry out a comprehensive policy in regard to research, in collaboration with the governmental authority.

The new President of the Institute of Sewage Purification, Mr. William T. Lockett, at his inauguration Nov. 27th, 1942, said that the excellent prospects for research under such a scheme of regionalization provided much justification for the adoption of the scheme. He was hopeful that regionalization, if adopted, would lead to the accumulation of funds for research in sewage treatment, without putting a burden on any section of the community at large. A contribution of only 1 per cent of the annual cost of sewerage and sewage purification would produce a national research fund of more than £100,000 per year.

This prospect appears attractive to all those interested in sewage research, and this includes almost every engineer, chemist or bacteriologist in the sewage disposal field. It may be possible that this scheme would result in more widespread study in England of stream pollution and sewage treatment, but this possibility would be only a secondary factor in accomplishing the establishment of regional authorities. The proposal will have to stand or fall on its economic and legal merits and not as a means for fostering research.

There is no doubt that the river basin is the natural administrative area for sewage and industrial waste treatment, but the difficulties that have been encountered in the U. S. in attempts to get several municipalities to work together regionally for sanitary improvements lead to the conclusion that regionalization would be difficult to establish here. One example of recent history is in the Calumet Region in Indiana, where all attempts at concerted regional action failed. Of course, if the Federal Government would subsidize sewage and industrial waste treatment on the basis of regional or river basin areas, there might be a trend toward regionalization, but without this incentive, the states find it difficult to organize river valley sanitation as a unit. The Potomac River project was to be subsidized by the government merely as a demonstration, and not as a precedent for other river valleys.

There are several important differences, however, between the river basin pollution problem in England and in America. Over there the rivers are small, distances are not great, cities are only a few miles apart, sewage treatment works date back a number of decades and are in great need of modernization, and the Ministry of Health has long exercised final authority on financing sewerage and sewage works construction. Here, however, river valleys are long and communities scattered, most of our treatment plants are new and modern, we now have more regional control through our state sanitary engineering divisions and our sanitary water boards than England has, and civic pride opposes regional control of funds and decisions. Also, probably we have been carrying on more widespread research than has been possible in England, with war and threats of war at her doorstep for so many years. As a matter of fact, it is astonishing and heartening that our English friends can even think and plan ahead as they have in these critical days of the war, and they deserve our congratulations for their courageous, forward-looking plans.

F. W. Mohlman

Proceedings of Local Associations

CALIFORNIA SEWAGE WORKS ASSOCIATION

Fifteenth Annual Fall Convention

Los Angeles, California, September 20–22, 1942

Sunday, September 20.—President Fred D. Bowlus called the Convention to order at 8:20 P.M. in the Victory Room of the Clark Hotel with 27 members present. After making several announcements he explained that the purpose of the meeting was to give the members an opportunity to discuss their operating experiences and problems on the subjects of sludge gas meters, sludge heating coils, digester scum, and trickling filter distributors. For the next hour practically all the members present entered into a very interesting and informative discussion on these subjects. All the remarks and suggestions were recorded by stenotype and will be printed in the *California Sewage Works Journal.*

Mr. Harold K. Palmer then reviewed the tentative standard specifications for sewage pumps, motors and controls as prepared by his committee which was recently appointed for this purpose. Considerable discussion, questions and suggestions were offered by the members as Mr. Palmer read each part of the specifications. The meeting was adjourned at 10:00 P.M.

Monday, September 21.—With 114 members present, President Bowlus opened the meeting at 9:15 A.M. The first paper on the program, "Shore Pollution Reduction at San Francisco" by Charles Gilman Hyde, Consulting Sanitary Engineer, Department of Public Health, San Francisco, was read by Mr. A. M. Rawn. The next paper was presented by Mr. J. L. McBride, City Engineer of Santa Ana, entitled "Orange County Joint Outfall and Sewage Treatment Plant" in which he reviewed the long standing problems peculiar to this 22-mile long outfall. Plans for the elimination of citrus by-product wastes from this Joint Outfall were explained by Mr. E. P. Hapgood, City Engineer of Anaheim, in his paper "Joint Land Disposal of Wastes from Three Citrus By-Products Plants." The Orange County Joint Outfall has also been burdened by cannery wastes from the City of Fullerton where attempts have been made to eliminate as much of the waste from the sewer as possible. Mr. Grover L. Walters, Superintendent of Water and Sewer Departments of this city, described the progress that had been made during the 1942 season in his paper, "Problems in Disposal of Peach and Tomato Wastes from the Largest Cannery in the West." The meeting was adjourned at 11:30 A.M.

A caravan of 25 cars assembled at 12:00 noon and proceeded to Long Beach where the Bixby pumping plant was inspected. This plant, constructed in 1942 to serve the new Navy Hospital and residential area, was of special interest because it does not have a wet well. Two variable-speed pumps with capacities from 200 to 1,400 g.p.m. each lift the sewage directly out of the 18 in. influent line into a 2,300 ft. force main.

The Pacific Coast Club was the next stop where the forty members of the Caravan were guests of the Long Beach Section of the American Association of Engineers at an excellent lunch. Mr. Herbert Davis of the Section welcomed the members of our Association and presented their host, Mr. D. R. Kennedy, Superintendent of the Pipe Lines Division for the City of Long Beach.

After lunch, the Caravan proceeded to the Los Angeles City Terminal Island treatment plant and then to the Los Angeles County Sanitation Districts sewage treatment plant. At the latter plant the recent developments in preheating and seeding of raw sludge were observed and the new digestion units under construction were inspected. Each digestion unit was composed of three abandoned activated sludge tanks, each 12½ by 12½ feet in section and 175 feet long, two of which were covered by a fixed wooden roof. The last stop of the Caravan was at the new Los Angeles City sewer ventilation plant.

Sixty-six members and guests attended the annual banquet which was held in the Victory Room of the Hotel Clark. The speaker of the evening was Elmer Belt, M.D., President, California State Board of Public Health. Dr. Belt presented a very enlightening address supported by lantern slides on the subject, "The California State Board of Public Health; Its Service to the People of Our State."

Tuesday, September 22.—There were twenty-five present at the joint breakfast with the members of the Public Works Officers Department. In the absence of Mr. Clayton W. Paige, President of this department, who is now in military service, Mr. J. A. Manchini acted as chairman and, after introducing the various members, presented the guest speaker, Mr. Jack Finch of the Premier Oil and Lead Works of Los Angeles. Mr. Finch gave an exceptionally interesting talk, illustrated with colored slides, on the latest developments in the art of camouflage.

President Bowlus presided over the joint meeting with the Public Works Officers Department of the League of California Cities. The meeting was called to order at 9:15 A.M. with 76 members present. The first paper, "Ventilation of Large Sewers by City of Los Angeles," was presented by H. G. Smith, Engineer of Sewer Design and Plant Operation for that city.

A very timely and instructive discussion was opened by Captain William T. Ingram, Assistant Sanitary Engineer, U. S. Public Health Service, Office of Civilian Defense, 9th Region, on the subject, "Protection of Sewage Works in War Time." Captain Ingram briefly summarized a plan for the operation of sewage works under war conditions both before and after damage occurs. Damage by sabotage or enemy action should be anticipated and Captain Ingram referred to sixteen wartime precautions for operators of sewage works suggested by Major

G. E. Arnold, Sanitary Engineer for the Ninth Regional U. S. Office of Civilian Defense, in a two page mimeographed bulletin distributed to all members attending the Convention. Serious thought should be given to the evaluation of the use of each part of the system by critical industries. The extent of possible damage by bombs and the effect of overloading of the sewerage system should be considered. Auxiliary operators should be trained and made familiar with the sewage works. Those in charge of supervision should be in complete co-operation and co-ordination with other departments and with their local civilian defense council.

After damage occurs, the questions of when to make repairs, extent of the health hazard, how and when to notify the water and health departments are of utmost importance. The possibility of danger from the effects of decontamination after a gas attack should be determined. The sewage works laboratory should be inventoried for the types of tests that could be utilized for other uses such as water testing. Community sanitation should be considered with the possibility of providing emergency privies in those areas where there is a minimum of open land as in apartment house districts. Mutual aid should be in effect not only between sewage works but with water works as well, keeping in mind the possibility of interchanging material and the use by the water department of the sewage plant chlorinators. Financial agreements should be arranged so that material, equipment, and labor can be quickly replaced or compensated for.

Captain Ingram called on the following public officials for their comments on this subject and a brief review of what their departments were doing or planning in the way of sewage works protection: D. R. Kennedy, of Long Beach; A. M. Rawn, of the Los Angeles County Sanitation Districts; H. P. Cortelyou, of Los Angeles; Walter N. Frickstad, of Oakland; Frank Rossi, of Modesto; Carl M. Hoskinson, of Sacramento; John A. Manchini, of Hayward; Harold L. May, of Palo Alto; R. D. Woodward, of Laguna Beach; R. F. Goudy, of Los Angeles; and Clyde C. Kennedy. The comments by these men indicated that considerable thought has already been given to the protection of the sewerage system from sabotage. The problem of sealing manhole covers was of particular concern as well as the protection of sewage plants from saboteurs. It was pointed out that anything and everything could be expected in the sewer. Of particular danger would be casing head gasoline which can penetrate through porous ground and even through brick manholes to enter the sewer. The inevitable loss of personnel will necessitate the training of additional help. The use of women should be considered for many of the jobs now done by men. Another point brought out was the importance of distinguishing between a health and a non-health hazard in connection with industrial wastes. At times of emergency the industrial wastes could be discharged into the storm sewers. In any case, the sewage plant operator should know what degree of treatment is necessary to meet health requirements.

Major G. E. Arnold ended the discussion on protection of sewage works during war times by emphasizing the following points: need for auxiliary power; prevention of flooding; complete maps; incident drills; gas masks. He pointed out that in case of a gas attack the gas pollution of sewage would be very dangerous. Vital points of the sewage plant should be protected by revetments made of sacks filled with mixed earth and asphalt. The sealing of vital manhole covers was of great importance especially over power vaults. Major Arnold concluded by sketching on the blackboard a detail of one method of sealing covers by bolting down with bolts having a five sided head which was recessed in the cover and seat so that a special wrench is necessary to remove the bolts.

The entire discussion was taken down by stenotype and will be printed in the next issue of the *California Sewage Works Journal.*

The first paper of the afternoon session, "San Bernardino Sewage Treatment Plant Revisions" prepared by David H. Currie, Engineer, Currie Engineering Company, was read by Mr. Hosgood, Assistant Superintendent, Water and Sewer Department, San Bernardino.

The meeting was opened for business at 2:00 P.M. and President Bowlus introduced Mr. E. B. Besselievre, Engineer for the Dorr Company, Inc., who has recently been transferred to the West Coast from New York. Mr. Besselievre had been requested by Mr. A. M. Kivari, chairman of the nominating committee, who was not able to attend the convention, to present the following report:

"The Nomination Committee recommends the following candidates for the various offices for the year 1943:

President—Carl M. Hoskinson, Sacramento
First Vice-President—Richard D. Pomeroy, Pasadena
Second Vice-President—Frank S. Currie, San Bernardino
Secretary-Treasurer—Jack H. Kimball, Santa Ana
Director (1947)—Willis T. Knowlton, Los Angeles

Respectfully submitted,

Nominating Committee:
A. M. Kivari, *Chairman*
John F. Skinner
Uno H. Erickson"

Mr. C. C. Kennedy moved that the report of the Nominating Committee be accepted, that nominations be closed and that the President cast a unanimous ballot for all the candidates. The motion was seconded by Mr. Arthur G. Pickett and so ordered.

President Bowlus announced the resignation of Mr. Carl F. Tennant from the Association and explained that Mr. Tennant had served only four of his five year term as Director of our Association. He then called for nominations for a Director to fill the one-year unexpired term. Mr. Wm. A. Allen nominated Mr. Jack C. Albers of Glendale. Mr. Reinke moved the nominations be closed. So ordered.

Committee reports were then called for. Mr. Arthur G. Pickett reviewed the work of the Membership Committee. The Publicity Committee was represented by a telegram from Chairman F. Wayland Jones who sent regrets that he was not able to attend and promised a report of his committee's activities by mail. President Bowlus then reviewed the financing and publishing of Volume XIV of the *California Sewage Works Journal.* Carl M. Hoskinson read his report on the Legislative Committee and the Secretary reviewed the work of the Committee on Schools and Certification in the absence of the Chairman, Kenneth W. Brown. A very complete report by the Pump and Motor Standards Committee was briefly reviewed by the Chairman, Mr. Harold K. Palmer. Dr. Richard D. Pomeroy reported that the Design Practice Committee had not functioned this year due to the present conditions and suggested that the committee be abandoned until after the war. A report on the Industrial Waste Committee was read by Mr. W. T. Knowlton. The Secretary-Treasurer's report was then presented and a brief review of the sources of income and the operating cost per member was given. Based on 243 active members, the operating expenses were $1.08 per member as against an income of $1.23. During the year, however, capital additions in the form of a four-drawer letter filing cabinet and a two-drawer card index file were purchased amounting to an additional cost of $0.19 per member, making a total expenditure of $1.27 per member and causing a deficit of $0.04 per member for the year 1942.

Under new business, Dr. Richard D. Pomeroy moved that there be only one meeting of the Association during the next year. Mr. Knowlton seconded the motion. Mr. Homer Jorgensen suggested that one meeting be held in the North and one in the South in order to reduce traveling. Mr. Wm. J. O'Connell was not in favor of splitting the state into two groups. Mr. Ed. A. Reinke suggested that there should be more meetings than two a year if comparisons were made to activities in England. Mr. J. C. Albers was in favor of meeting at the same time as the League of California Cities. Mr. Besselievre stated that the New York Sewage Works Association meets jointly with the American Society of Civil Engineers for its annual meeting but that local sections meet several times a year and have programs designed for the operator. Mr. Wm. T. Ingram warned against complications resulting from requirements of our constitution in regard to meetings and elections. He was also of the opinion that if the one meeting was held in conjunction with the League meeting, many operators would not be able to attend. This would be all right if local section meetings were organized. Mr. Koebig believed more operators would attend if meetings were held with the League. Mr. Ramseier stated that the Spring meetings had always been superior to the Fall meetings and suggested that the attendance facts be obtained. Mr. Wm. A. Allen was of the same opinion and suggested that the members be contacted for their expression. Mr. Jorgensen stated that after listening to the arguments pro and con he was still of the opinion that it would be best to have meetings in the north and south because of less cost and transportation. Mr. Harold F. Gray stated that one of the duties of the Governing Board was to pick the time and place of the meetings and it should therefore not shift its responsibility on to the membership represented at this meeting. Mr. Gray moved that the motion before the meeting be tabled. Seconded and so ordered.

Before turning over the meeting to the newly elected president, Mr. Carl M. Hoskinson, President Bowlus expressed his appreciation to the membership for their co-operation throughout the year and then extended his best wishes to Mr. Hoskinson.

President Hoskinson announced that the Governing Board at its meeting on Monday had authorized the President to appoint a committee called the "Emergency Sewerage Protection Committee" with power to act. The aim of this committee was to obtain information and prepare plans for the self-protection and mutual aid of sewerage works in California. This committee would function for the Association but would offer its findings to the Sub-committee on Water Supply, Committee on Transportation, Housing, Works and Facilities, California State Council of Defense. Professor Charles Gilman Hyde was tentatively appointed Honorary Chairman of this committee which was divided into a northern and southern group headed by Mr. Harold F. Gray and C. R. Compton respectively, as vice-chairman of each group. Members of the northern group were John J. Casey, Walter N. Frickstad, E. A. Reinke, Wm. T. Ingram, and W. W. White. Members appointed to the southern group were Wm. A. Allen, R. F. Goudy, R. D. Phelps, H. P. Cortelyou, and R. T. Gardner.

Mr. W. T. Knowlton moved that a rising vote of thanks and appreciation be given to the retiring president, Mr. Fred D. Bowlus. So ordered—in a big way.

President Hoskinson announced that the Federation of Sewage Works Associations was having its Third Annual Convention at Cleveland on October 22 to 24, 1942, and that Mr. Wm. A. Allen, our representative on the Federation Board of Control, was planning to attend. Mr. Ramseier requested that Mr. Allen find out whether or not the Federation is planning to publish monthly Journals as originally promised and why they had not published some very excellent papers which had recently been presented before the California Sewage Works meetings. Mr. Ramseier referred to two papers, one presented by Harvey F. Ludwig and Russell G. Ludwig entitled "Laboratory Flocculation of East Bay Sewage and the Mechanism of Flocculation in Water Purification and Sewage Treatment Practice" and the other "Detection of Metallic and War Gas Poisons in Sewage" by R. F. Goudy. The papers were never published in the SEWAGE WORKS JOURNAL and in his opinion they should have been. Mr. Harvey F. Ludwig added that in his opinion the critical review of literature as published in the March, 1942, issue of the SEWAGE WORKS JOURNAL was not critical as it did not include any articles published in the *California Sewage Works Journal*. Dr. Richard D. Pomeroy suggested that perhaps our Association should not publish these papers which would be published in the SEWAGE WORKS JOURNAL but could print an abstract of them. Mr. Wm. T. Ingram stated there had been a long-standing difference of opinion on the matter of prior printing rights, and because the Editor of the SEWAGE WORKS JOURNAL has not been able to advise authors or the Editor of our Journal if and when papers will be published it has been the policy of this Association to print all papers in our Journal.

Mr. Allen stated that he would convey the thoughts of the members to the Federation at the coming meeting in Cleveland.

The meeting was adjourned at 3:22 P.M.

JACK H. KIMBALL, *Secretary*

NEW YORK STATE SEWAGE WORKS ASSOCIATION

Fifteenth Annual Meeting

New York, New York, January 21–22, 1943

The Fifteenth Annual Meeting of the New York State Sewage Works Association was held in New York City on January 21 and 22, 1943, with headquarters at the Hotel McAlpin. About 250 members and guests were registered. This number was somewhat more than was anticipated because of the difficulties of transportation and because of the increased work by members of the Association due to war conditions.

George Symons, Chief Chemist of the Buffalo sewage treatment plant, Buffalo, New York; George W. Moore, District Sanitary Engineer, New York State Department of Health, Rochester, New York; and Herbert O. Johnson, Superintendent of Belgrave Sewer District, Great Neck, New York, were elected to the Executive Committee for a period of three years. Edward J. Smith, Superintendent of Sewage Treatment, Niagara Falls, New York, was elected President and William H. Larkin, District Sanitary Engineer, New York State Department of Health, New York City, was elected Vice-President for the year of 1943. A. S. Bedell of the New York State Department of Health, Albany, New York, was reappointed Secretary-Treasurer. J. C. Brigham also from the Health Department, Albany, New York, and A. W. Eustance, District Sanitary Engineer of the New York State Department of Health from Geneva, New York, were reappointed Assistant Treasurer and Assistant Secretary, respectively, for the ensuing year.

The program was arranged so that the members of the Sewage Works Association could attend the Thursday session of the Sanitary Engineering Division of the ASCE, and likewise, so that members of the ASCE could attend the technical sessions of the Sewage Works Association on Friday.

At the general business meeting on Friday, it was noted that the Association now has a membership of 655 and that at the present time there are five active local sections in the state. The reports of the activities of these local sections and of the various standing committees of the association were presented and discussed at the meeting.

At the technical session on Friday morning, Mr. Paul Hansen of the firm of Greeley and Hansen, read a paper prepared by Paul E. Langdon of that firm entitled "A Sewerage Project Designed Without Critical Materials." In this paper it was brought out that it would be possible to build a sewage treatment works without use of any critical materials, but such a practice was not usually practical. Before 1900 many sewage treatment works were constructed without what we now consider critical materials, as for example, the intermittent sand filter plant. Later designs provided for the use of much critical material; but since there is now a need of this material in the armed forces, it is necessary to limit the amount now used for domestic purposes. In determining the amount of critical material which should be used, the question of the life of the structure should be considered; and if the structure is for a short time only, the amount of critical materials should be less than for one built for more permanent use.

This paper was discussed by A. M. Rawn, Chief Engineer and General Manager, County Sanitary Districts of Los Angeles County, California, and in his discussion he brought out the fact that construction without the use of critical materials is frequently not economical as, for example, much heavier walls are needed if designed without reinforcement than would be needed if reinforcing were to be used. In a further discussion of this paper Commander Stanley Barker of the U. S. Navy referred to a recent directive issued by the Navy. This directive indicates that although the Navy desires to co-operate as fully as possible with local and state health authorities in providing adequate sewage treatment facilities for its various new or enlarged shore stations, the very minimum of treatment and only present needed capacities must be constructed in order to conserve critical materials and equipment.

At the luncheon meeting, George J. Schroepfer, Chief Engineer of the Minnesota-St. Paul Sanitary District and President of the Federation of Sewage Works Associations, gave a brief report on the activities of the Federation. He advised that a post war planning committee had been appointed by the Federation with A. M. Rawn of Los Angeles as Chairman.

The Kenneth Allen Memorial Award for the most meritorious paper of an engineering and research nature was presented to Professor Earle B. Phelps and John Bevan, his associate, by N. L. Nussbaumer, Chairman of the Kenneth Allen Memorial Committee. The title of the paper winning the reward was "A Laboratory Study of the Guggenheim Bio-Chemical Process," published in the January, 1942, issue of this JOURNAL. The award was accepted by Mr. John Bevan in the absence of Professor Phelps.

Herbert H. Wagenhals, Past President of the Association, was presented with a certificate by Charles Velzy, President.

Charles R. Velzy, the retiring President, was presented with the gold key bearing the emblem of the Association by Mr. H. H. Wagenhals.

The joint luncheon was followed by a forum led by Linn H. Enslow on "The Influence of the War on Sanitary Engineering." Participants in this forum were Charles A. Holmquist, Director of the Division of Sanitation of the New York State Department of Health, representing the state engineer; Charles Gilman Hyde of California, representing the educator; William M. Piatt of North Carolina, representing the designer; and George J. Schroepfer of Minnesota, representing the operator. In his discussion, Mr. Holmquist pointed out the increased activities of engineers in the New York State Department of Health due to war activities. He also pointed out the shortage of engineers trained in this work and the fact that the various universities throughout the country were not training a sufficient number of men in this profession to fill the normal needs, not to speak of the wartime needs. Professor Hyde of California stated that he expected that the need for sanitary engineers for foreign service would continue for some time after the war. He also hopes that engineering schools in revising their programs to train sanitary engineers will place particular emphasis on fundamental courses in sanitary chemistry, bacteriology, and allied subjects in environmental sanitation. Mr. Piatt of North Carolina pointed out the advantages to the armed forces of good sanitation and advised that the problem of disease in the present army is considerably less than in previous armies due to improved sanitary conditions. Mr. Schroepfer of Minnesota pointed out some of the problems of the operator of sewage treatment plants. Other participants in this forum were A. M. Rawn of California, Charles R. Velzy of Buffalo, and Nathan Kass of New York City.

In the afternoon session, Dr. A. J. Fischer of the Development Department of the Dorr Company in New York City, gave a paper entitled "Vacuum Flotation of Sewage and Industrial Wastes." This paper was discussed by Dr. Harry Gehm of the New Jersey Agricultural Experiment Station and by R. F. Coltart of the Link Belt Company. A paper entitled "Grease Removal by Flotation" was presented by Capt. Rolf Eliassen of the Corps of Engineers, with a discussion by Mr. W. Donaldson of New York City. These papers created considerable interest but time did not permit any extended discussion of the subject. A paper entitled "Overhauling a Methane Gas Holder" was presented by C. George Andersen of Rockville Centre, New York.

On Friday evening the members of the NYSSWA and the ASCE enjoyed the usual annual banquet and were greeted by Major Ezra B. Whitman, President Elect of the ASCE. George T. Seabury, Executive Secretary of the ASCE, also addressed the group, giving "Some Reminiscences." William J. Orchard as Master of Ceremonies very graciously introduced the various speakers, led the exhilarating group singing and provided a pleasing bit of entertainment at the close of the speaking.

The highlight of the entire program was an address by Abel Wolman, Professor of Sanitary Engineering, Johns Hopkins University, entitled "The Sanitary Engineer in a Post War World." Dr. Wolman pointed out the very favorable position of the sanitary engineer at present and to be expected in the future. He also pointed out the need of careful post war planning to be undertaken at the present time. Such post war planning would not only be beneficial in the future, but it has a tendency to increase the morale at the present, which is very important. He stated that most of our allies, including England and even China, are now engaged in planning post war projects.

The usual Saturday inspection trip was not undertaken this year because of the difficulties of transportation.

The next meeting of the Association will be in Rochester, New York, in June, 1943.

A. S. Bedell, *Secretary*

LOCAL ASSOCIATION MEETINGS

Association	*Place*	*Date*
Central States	Chicago, Illinois	Oct. 21–23, 1943
Federation of Sewage Works Associations	Chicago, Illinois	Oct. 21–23, 1943
New Jersey	Trenton, N. J.	March, 1943
New York State	Rochester, N. Y.	June 4–5, 1943
North Carolina	Grand Forks, N. D.	Nov. 1–3, 1943
North Dakota	Denver, Colorado	Sept. or Oct., 1943
Ohio Conference	Mansfield, Ohio	June 23, 1943
Pennsylvania	Harrisburg, Pa. (Penn Harris Hotel)	June 9, 1943
Rocky Mountain	College Station	Sept., 1943
Texas	Texas A. &. M. College	Feb., 1943

CORRECTION

On page 125 of the January, 1943, issue of This Journal an error was made in designating the second Vice-President of the New England Sewage Works Association. This should be Mr. Frank L. Flood of Boston and not Mr. Frank W. Van Kleeck of Hartford.

Federation Affairs

IMPORTANT PRIORITIES CHANGES ANNOUNCED

Preliminary instructions concerning the application of the new Controlled Materials Plan (CMP) to sewage works priorities were announced by the War Production Board in February. The new plan becomes effective April 1, 1943, although orders will be filled until June 30 when they carry preference ratings unaccompanied by the new CMP allotment numbers or allotment symbols. However, orders carrying CMP allotment numbers or symbols will take precedence over orders carrying preference ratings of the same rank. After June 30, all orders for controlled and some other critical materials must carry the new allotment number or symbol, as may be required.

For instructions and information regarding the application of CMP to maintenance, repair and operation supplies, obtain a copy of CMP Regulation No. 5 (February 9, 1943) and CMP Regulation No. 3 (February 9, 1943). Changes in project procedures for new construction and facilities are contained in Utilities Administrative Letter of February 6, 1943, issued by the Power Division of WPB. The new Form CMP-4C should also be studied.

Copies of the above regulations, letters, and forms may be obtained from your nearest WPB Field Office or by request from Mr. Herbert S. Marks, Acting Director, Power Division, War Production Board, Room 2085 Temporary Building R, Washington, D. C.

W. H. Wisely, *Secretary*

THE SANITARY CORPS, U. S. ARMY

Editor's Note: The Journal has been requested by Major J. J. Gilbert to give publicity to the needs of the Sanitary Corps for officers. Commissions as First Lieutenant and Captain are available for properly qualified men within certain age limits. For further information, please write Major Gilbert, Office of the Surgeon General, Washington, D. C.

In January, 1943, Major Gilbert forwarded a list of Sanitary Corps Engineers who are members of the Federation of Sewage Works Associations, with the request that the list be published in Sewage Works Journal. He stated, "I believe you should insert the note that this is a list of sanitary engineers only and does not include the bacteriologists and biochemists who are members of the Federation. These men are handled by another branch and their lists are rather incomplete. I do not believe that many of our bacteriologists and biochemists are members of the Federation as our qualifications require that these men be trained in hospital work, which limits the field for water and sewage men."

Further, Major Gilbert states, "You will find that Army Post Office numbers are given with reference to the officers (as of January 1, 1943) and bear no relation to where they are stationed. I will begin to bring this list up to date and you may wish to publish it in a future issue as a supplement."

SANITARY CORPS ENGINEERS WHO ARE MEMBERS OF THE FEDERATION OF SEWAGE WORKS ASSOCIATIONS

Name	Last Civilian Position	Present Assignment (January 1, 1943)
Adams, Major C. L.	Sanitary District of Chicago	Fort Custer, Mich.
Agar, Capt. C. C.	N. Y. State Health Dept.	Camp Rucker, Ala.
Anderson, Lt. H. A.	U. S. D. A. Farm Security Admr.	Camp Atterbury, Ind.
Balmer, Lt. R. R.	U. S. Public Health Service	APO 3310, New York, N. Y.

Name	Last Civilian Position	Present Assignment (January 1, 1943)
Baty, Lt. James B.	Queens Univ., Canada	Ofc. of the Div. Engineer, North Atlantic Div., 270 Broadway, New York, N. Y.
Bjelajac, Lt. Vaso	Corps of Engineers, U. S. Army	AAF, Brookley Field, Ala.
Blew, Lt. Col. M. J.	Northeast Works, Phila.	Hqs. 4th Service Command, Post Office Building, Atlanta, Ga.
Bogost, Lt. M. S.	U. S. Corps of Engineers	APO 632, Miami, Fla.
Bogren, Capt. G. G.	Weston & Sampson, Engrs.	Dow Field, Bangor, Me.
Bosch, Capt. H. M.	Minn. Dept. of Health	Hqs. 7th Service Command, 15th and Dodge Streets, Omaha, Nebraska
Brown, Lt. J. L.	Cannon Mills Company	15th Malaria Control Unit, Camp Harrihan, New Orleans, La.
Bryan, Lt. W. D.	City of Tarboro, N. C.	Camp Adair, Oregon
Clark, Major Lloyd K.	N. D. State Health Dept.	Surg. Gen. Ofc., Washington, D. C.
Clark, Major R. N.	N. Y. State Dept. of Health	Hqs. 1st Service Command, 808 Commonwealth Ave., Boston, Mass.
Cleland, Major R. R.	Boro of State College, Pa.	APO 887, New York, N. Y.
Connell, Capt. C. H.	Prof., College Station, Tex.	Carlisle Barracks, Pa.
Conger, Capt. C. C.	City Engr., Claremont, Cal.	AFRTC, Santa Ana, Calif.
Edwards, Lt. S. W.	Texas State Health Dept.	U. S. Engr. Office, U.S.A., Miami, Florida
Fleet, Lt. G. A.	N. Y. State Health Dept.	Camp Davis, N. C.
Foster, Capt. H. B.	Calif. State Dept. of Health	Camp Callan, Calif.
Frith, Capt. G. R.	Ga. Dept. of Health	Hqs. 8th Service Command, Santa Fe Bldg., Dallas, Tex.
Garland, Lt. C. F.	Fla. State Board of Health	Camp McCain, Miss.
Gilbert, Major Joseph J.	Link-Belt. Co., Phila., Pa.	Surg. Gen. Ofc., Washington, D. C.
Goff, Lt. J. S.	Post Util. Ofc., Camp Edwards, Mass.	Hampton Roads Port of Emb., Newport News, Va.
Gotaas, Capt. H. B.	Prof., Univ. of N. C.	Ofc. for Emergency Mgmt., Div. of Health & Sanitation, Washington, D. C.
Hardenbergh, Col. W. A.	Public Works Magazine	Surg. Gen. Ofc., Washington, D. C.
Hardy, Lt. W. R.	City of Fort Worth, Texas	Camp Swift, Texas
Hatch, Lt. Col. B. F.	Burgess & Niple, Columbus, Ohio	Corps of Engineers, Repairs & Utilities Branch, Columbus, Ohio
Heiple, Lt. Loren R.	Iowa State College	O'Reilly Genl. Hospital, Springfield, Missouri
Hicks, Lt. G. W.	Chicago Pump Company	Fort Sheridan, Ill.
Hill, Lt. M. T.	N. Y. State Dept. of Health	Fort Lewis, Wash.
Horton, Lt. R. K.	Univ. of North Carolina	Ofc. for Emergency Mgmt.
Iscol, Capt. G.	N. Y. C. Dept. of Public Works	Hqs. 8th Service Command
Karalekas, Lt. P. C.	Mass. Dept. of Health	Ofc. for Emergency Mgmt.
Keller, Capt. L. M.	N. Y. State Health Dept.	Camp Claiborne, La.
Kiker, Lt. J. E.	N. Y. State Health Dept.	Hqs. 4th Service Command
King, Lt. Richard	Univ. of Connecticut	Ft. Belvoir, Va.
Kochin, Lt. M. S.	Pa. Dept. of Health	Camp Livingston, La.

Name	Last Civilian Position	Present Assignment (January 1, 1943)
Krell, Lt. A. J.	Private Engineering Firm	Pine Camp, N. Y.
Kremer, Lt. R. W.	Pa. Dept. of Health	Ft. Lewis, Wash.
Kronbach, Lt. A. J.	City of Monroe, Mich.	Selfridge Field, Mich.
Lee, Capt. David B.	Fla. State Health Dept.	Camp Haan, Calif.
Leh, Capt. Willard	War Dept., Wash., D. C.	Ft. Eustis, Va.
Leland, Lt. R. I.	Illinois Dept. of Health	Camp Howze, Texas
Lesher, Lt. Carl E.	H. K. Ferguson Co., Phila.	Ft. Hancock, N. J.
Lieber, Capt. Maxim	N. Y. State Conservation Com.	Luke Field, Ariz.
Lose, Lt. C., III	N. Y. State Dept. of Health	Camp Lee, Virginia
Martin, Lt. S. C.	Illinois Dept. of Health	Camp Roberts, Calif.
Marzec, Lt. E. J.	Iowa Dept. of Health	Camp Barkeley, Texas
McKee, Lt. F. J.	Wisc. State Health Dept.	AAF, Tech. School, Madison, Wisc.
Milliken, Lt. H. E.	City of Auburn, N. Y.	Bombing and Gunnery Range, Tonopah, Nevada
Moggio, Lt. W. A.	Piatt & Lee, Engr. Corp.	Camp Van Dorn, Miss.
Okun, Lt. D. A.	U. S. Public Health Service	Ofc. of Division Engr., North Atlantic Div., 270 Broadway, New York, N. Y.
Pierce, Major C. L.	Panama Canal Zone Health Dept.	APO 834, New Orleans, La.
Poole, Capt. B. A.	Indiana Board of Health	Camp Campbell, Ky.
Porter, Lt. Wm. L.	Missouri Board of Health	Air Force Tech. School, Goldsboro, N. C.
Reidell, Lt. A. C.	The Dorr Co., Inc.	Camp Young, Calif.
Riley, Capt. H. M.	N. Y. State Dept. of Health	Fort Bragg, N. C.
Ross, Lt. H. M.	American Skein & Edry Co.	715th Med. San. Co., Ft. Riley, Kansas
Roznoy, Lt. L. W.	N. J. Sewerage Comm.	Hampton Roads Port of Emb., Newport News, Va.
Salvato, Lt. J. A.	N. Y. Dept. of Health	Ft. George G. Meade, Md.
Sampson, Lt. J. A.	Iowa Dept. of Health	Camp Robinson, Ark.
Schade, Lt. W. F.	Cleveland, Ohio	Fitzsimons Genl. Hosp., Denver, Colo.
Sherman, Lt. L. K.	Conn. Dept. of Health	AAFTS, Atlantic City, N. J.
Stewart, Capt. F. D.	Ohio Dept. of Health	APO 3310, New York, N. Y.
Stilson, Major A. E.	Morse Boulger Company	Hqs. 5th Service Command, Ft. Hayes, Columbus, Ohio
Stowell, Lt. E. R.	U. S. Corps of Engineers	Camp Gruber, Oklahoma
Sweeney, Lt. Col. R. C.	N. Y. State Health Dept.	APO 887, New York, N. Y.
Torpey, Lt. Wilbur N.	Dept. of Pub. Wks., New York	Fort Monmouth, N. J.
Trager, Capt. L. W.	N. H. State Board of Health	Camp Carrabelle, Fla.
Van Breda, Lt. A. J.	City of Springfield, Ill.	Hqs. 8th Service Command
Vogel, Lt. P. W.	Md. State Dept. of Health	Morris Field, Charlotte, N. C.
Watkins, Capt. W. W.	City of Oneonta, N. Y.	Camp Wheeler, Ga.
Weir, Major W. H.	Georgia Health Dept.	Camp Myles Standish, Mass.
West, Capt. Leslie E.	Joint Meeting Sewer Comm.	Fort Devens, Mass.
Whitley, Capt. F. H.	Prof. N. Y. University	Officer Trng. School, Miami Beach, Fla.
Williamson, Lt. A. E.	Fla. Board of Health	Ofc. for Emergency Mgmt.
Winch, Lt. N. M.	Asst. City Engr., Needham, Mass.	Fort Brady, Mich.
Wirth, Lt. H. E.	Wisc. Board of Health	Harding Field, La.
Woodward, Capt. F. L.	Minn. Health Dept.	Drew Field, Fla.

DISCUSSION OF PAPER BY GEORGE J. SCHROEPFER "AN ANALYSIS OF STREAM POLLUTION AND STREAM STANDARDS"

This JOURNAL, September, 1942, Page 1051

By WARREN J. SCOTT

Director, Bureau of Sanitary Engineering, Connecticut State Department of Health, Hartford, Conn.

Editor's Note: Mr. Scott has asked Mr. Schroepfer to clarify a quotation referring to classification of outdoor bathing beach water by the Connecticut State Department of Health and the Joint Committee on Bathing Places of the Conference of State Sanitary Engineers. Mr. Schroepfer wrote the following letter to Mr. Scott dated Jan. 13, 1943. Mr. Scott replied on Jan. 16: "I think Mr. Schroepfer's letter covers the situation in excellent fashion and hope his letter may be published."

MINNEAPOLIS–SAINT PAUL SANITARY DISTRICT

January 13, 1943.

Dr. F. W. Mohlman
910 So. Michigan Ave.
Chicago, Ill.

Dear Dr. Mohlman:

I have received a letter from Mr. Warren J. Scott, Director of the Bureau of Sanitary Engineering of the Connecticut State Department of Health, with reference to the paper "An Analysis of Stream Pollution and Stream Standards" published in the September, 1942, issue of the SEWAGE WORKS JOURNAL. In his letter Mr. Scott points out that the classification table presented on page 1051 of this paper as it relates to the Connecticut State Department of Health does not present a true picture of the classification made by that department. The classification presented in the paper contains three headings: (1) The Class—such as (a), (b), (c), (d); (2) The Condition—such as "good," "doubtful," "poor," and "very poor," and (3) The Average *B. Coli* Count Allowable Under the Different Classifications. He points out that the condition description should be deleted from the compilation since that basis of classification was made as a result of sanitary surveys as distinguished from bacteriological tests which form the main basis for the classifications shown. In his letter, however, he mentions that in a previous paper by him entitled "Survey of Connecticut Shore Bathing Waters" (Conn. Health Bulletin Vol. 45, No. 12, Dec. 1931) he did state: "Naturally Class A represents good conditions, as disclosed by the sanitary survey; Class D represents very poor conditions on the same basis; Class B might be considered to represent fair to doubtful conditions; and Class C would include doubtful to poor conditions. The two intermediate classes are somewhat difficult of definition." From Mr. Scott's standpoint, therefore, the correlation of the class of water and the condition of the water as described by the terminology "good" to "very poor" should not have been made.

As Chairman of the Joint Committee on Bathing Places of the Conference of State Sanitary Engineers and the APHA, Mr. Scott calls attention to the following: "The Joint Committee does recommend classification studies but points to the importance of both the sanitary survey data and the bacteriological analysis data without tying them up as was done in the tabulation listed. Furthermore, the Joint Committee states in its published report: 'It is perhaps reasonable to conclude that, subject to interpretation of analytical studies from proper angles, waters better than the lower limit (1,000 *Escherichia coli* per 100 ml.) are fairly acceptable.'"

The classification shown in my paper was not one made by me, but rather was extracted verbatim from a source which I considered official and reliable. I am sorry that I could not now locate the original source of this classification so that Mr. Scott could arrange for a similar clarification in that paper. The writer would suggest, however, that anyone making use of this section of the paper relating to the classification of Connecticut waters refer to the paper by Mr. Scott previously mentioned, and a subsequent one by the same author entitled "Classification of Inland and Shore Waters" which also appears in the September 1942 issue of the JOURNAL.

While the distinction in classification, as pointed out by Mr. Scott, may appear to some to be a rather fine point, I would appreciate it, assuming it does not conflict with your usual policy, if you could arrange to publish this statement of Mr. Scott's position in a subsequent issue of the JOURNAL.

Yours sincerely,

GEORGE J. SCHROEPFER,
Chief Engineer and Superintendent

AID FOR SEWAGE WORKS PRIORITIES

Editor's Note: Our President, Mr. Schroepfer, has been very active in attempts to ease the priorities situation as it refers to sewage works and sewerage systems. He has been to Washington several times, in conference with Consultants Linn Enslow and Wm. Raisch, of the Sanitary Engineering Section of the American Society of Civil Engineers. When passing through Chicago from Washington on March 5, Mr. Schroepfer outlined the present status of the negotiations as follows:

> The Consultants have offered for the consideration of the Governmental Division of the WPB, in the field of Sewerage and Sanitation, the following recommendations:
>
> (1) That an operating section known as the "Sewerage and Sanitation Section" be established in the Governmental Division.
>
> (2) That this section be charged with the supervision of all priorities matters relating to construction, alterations or additions, maintenance and repairs of sewage and wastes collection, pumping and treatment facilities, garbage and refuse collection and disposal facilities.
>
> (3) That the proposed new section be authorized to make recommendations to the Director of the Governmental Division on matters pertaining to maintenance, repairs and operation covered by Order P-141 (and allied or future amending orders). For new construction, alterations and additions, existing organizations to be utilized for processing, stripping, etc.
>
> (4) It is suggested that a Section Chief of proven administrative ability and nationally recognized in the field of sewerage and sewage treatment practice be appointed and that he be given the necessary technical assistance to carry out the desired objectives.

Mr. Schroepfer stated that he believes the Hon. Maury Maverick, Director of the Governmental Division of the WPB, and Mr. Donald Nelson, look upon this proposed set-up with favor, but printing deadline will not permit us to wait to announce any further developments. At any rate, we know our President is in there pitching.

F. W. MOHLMAN

Reviews and Abstracts

THE MAINTENANCE, OPERATION AND CONTROL OF SEWAGE TREATMENT PLANTS

By E. J. Hamlin

Reprint from the *Transactions of the Minutes of Proceedings of the South African Society of Civil Engineers*, 1942. 43 pp.

This paper describes methods and means used in overcoming difficulties in operation and maintenance of the sewage disposal plants of the city of Johannesburg, South Africa, during these times when many materials are unobtainable.

Delta Activated Sludge Plant

When the war started in 1939 the flow at the Delta Works was approaching the design limit and it was contemplated installing further compressor capacity. Many military camps were established within the area served by the works, and many factories in the area more than doubled production. Thus the flow suddenly increased beyond the design limits.

The treatment units at this works include coarse screens, grit channels, four circular hopper bottomed sedimentation tanks, and four aeration tanks, each with four channels 165 ft. long, 10 ft. wide and 10 ft. deep and two square settling tanks with conical hopper bottoms. The activated sludge effluent is passed through sand filters and then on to land. Sludge is handled in digestion tanks and on drying beds.

With the increased load coming to the plant bulking became serious. In the original design provision was made for reaeration of sludge, approximately 25 per cent of the aeration tank volume being available for this. The increased flow prohibited the use of such a large volume of tankage for this purpose and a smaller volume could not be used without extensive changes. Accordingly it was decided to build a separate unit for sludge reaeration, and to pump the return sludge from the final settling tanks, dispensing with the air lifts provided for this purpose. In this way air for reaeration was available without increasing compressor capacity. Provision is made for a detention period of 8 hours in this unit. Sludge drawn from the final settling tanks is collected in a dividing chamber adjacent to the pump sump. It is possible to divert the sludge from any one settling tank to the primary digestion tanks or to the incoming sewage. At the dividing chamber any predetermined quantity may be passed to the reaeration tank. Following the tank reaerated sludge is passed to a conical dividing tank where the flow is split into four lines leading to the aeration tanks. Excess sludge is returned to the incoming sewer. Settled mixed sludge may be passed directly to the dividing tank, thence to the aeration units.

The reaeration unit was placed in service December 12, 1941. Starting on January 7, 1942, flow through the unit was stopped at 9 P.M. each night, the contents aerated throughout the night, and released to aeration channels at 7 A.M. During the night hours the return sludge pumps discharged directly to the conical dividing tank. The following table shows chemical data on the activated sludge and diffused air or primary effluent.

One gratifying result of the new scheme has been the almost complete elimination of rising sludge in the final settling tanks during the late afternoon. It still does occur occasionally, usually on Mondays and Tuesdays, but there have been weeks at a time when it did not occur.

On January 2, 1942, there was a violent rain storm which resulted in much fine soil being carried to the plant. The activated sludge density increased overnight from 0.30 to 1.64. On the dry basis the sludge was 70 per cent ash in contrast to the usual 30

	Sludge Density	Nitrogen as: Nitrite P.P.M.	Nitrogen as: Nitrate P.P.M.	Per Cent Purification
1941				
June	0.16	.015	.02	63
July	0.17	.008	.01	67
August	0.17	.009	.02	63
September	0.15	Nil	Nil	52
October	0.19	.008	Trace	53
November	0.20	.077	.06	66
December	0.19	.033	.08	72
1942				
January	0.65	.023	.18	81
February	0.75	.024	.20	78
March	0.70	.023	.28	76
April	0.83	.005	.22	84

per cent. In view of the improvement in the sludge characteristics it was decided to add soil whenever the sludge density fell below 0.50. Soil was put in a small tank fitted with an air diffuser and a hose connection for adding water continuously. It was calculated that the ratio of fine soil added per day to the total mineral matter present in the total activated sludge of the plant was 1: 60–70. No increase in the mineral matter of the sludge was noted as time went on. However, the sludge density never fell below 0.5 and in May reached a high of 1.4. Early in May the addition of soil was stopped and the aeration tanks drained, one by one, for inspection and replacement, where needed, of diffusers. Appreciable deposits of fine soil and silt were found. A permanent unit for the addition of soil is to be added at a later date. It will be added to the settled mixed sludge prior to the reaeration tank.

Cydna Sewage Disposal Works

At the Cydna works the problem faced was that of caring for very high peak flows which overloaded the sedimentation tanks, resulting in a large amount of solids being carried over to the primary filters. It was suspected that this was the cause of a heavy infestation of filter flies on the primary filters.

The drainage area served by the works is in the form of a sector of a circle with the plant at the center. There is no long outfall sewer from the whole or any portion of the drainage area and generally the slopes of the branch and intercepting sewers are steep. Hence, flows from all parts of the area reach the works at about the same time. The peak flow lasts about an hour and is approximately 3½ times the average flow.

One scheme contemplated was the construction of additional sedimentation tanks to give the desired period at peak flow. It was feared that septic conditions might be encountered unless the flow was increased during minimum flow periods by recirculation. It was estimated that for successful operation the pumps would have to be operated about 20 hours per day.

The other scheme contemplated the construction of a balancing tank to receive flow above that which could be handled by the sedimentation tanks. It was recognized that the storage of sewage in such a tank would lead to trouble. Three rotary compressors were available and it was decided to design the tank as a diffused air tank to be operated on the "fill-and-draw" method. The additions, completed early in 1941, consisted of an automatic weir, two small hopper-bottomed rough sedimentation tanks, aeration unit with a longitudinal furrow and a water depth of 10 ft., a circulation pump, and a floating draw-off arm and draw-off valves.

The unit is operated as follows: At 6 A.M. the compressors are started and the sludge in the furrows is churned up. The peak flow over a predetermined rate is passed to the roughing tanks, thence to the aeration unit. When flow starts to the aeration unit the circulation pump is started; it is kept running till about 5 P.M. when it is shut down along with the compressors. Thus an aeration period of 10 hours is provided. After aeration the effluent is decanted off by means of a floating arm and three valves fixed at different levels. Sludge is left in the lower 25 per cent of the tank volume. The first 3 ft. drawn is gravitated to the filter beds and the next 3 ft. is passed around the filters to the humus tanks.

To insure freedom from odors a small compressor is run at intervals through the night. It has been the experience at Johannesburg that some nitrites, if not nitrates, must be maintained in order to prevent odors.

A second peak flow arrives at the plant about 6–7 P.M. and when necessary it is contemplated giving two fillings per day.

Klipspruit Disposal Works

The sewage treated at this works is reputed to be the strongest in the world. Practically all industrial wastes are treated at this plant, and in addition the bucket contents from all unsewered areas. Several new features were introduced in the design of these works. Three of these which may be of interest are here described.

Flow Dividing Tank.—In the design of the new works at the Klipspruit Disposal Works various methods of distributing the flow equally between the 16 settling tanks were considered. The design adapted seemed to fulfill the requirements. These were: equal distribution at all flows to all settling tanks, simple and automatic in operation, simple to construct with low maintenance cost, and small loss of head and minimum area required.

The design consisted of a hopper-bottomed tank, the lower portion conical in shape and the upper portion developed into an octagon. In each of the eight sides there are installed two 42 in. rectangular weirs which discharge into individual compartments, each of these in turn connected by an 18 in. line to a settling tank. Flow to any tank can be shut off at the dividing tank. The tank is approximately 28 ft. deep below the weir crests and is 30 ft. 6 in. in diameter at the top. The sides of the hopper form an angle of 30° with the vertical. Sewage is fed upwards through a 48 in. diameter pipe on the vertical axis of the tank terminating approximately 2 ft. 10 in. below the weirs. The unit was designed for an average flow of 16 M.G.D. (Imp.).

Little settlement with the short retention period, about six minutes, was expected, though a pipe for drawing off sludge was provided. However, it was found that considerable matter did settle, mostly bits of paper, tea leaves, and paunch contents from the abattoirs. These solids formed a dense fibrous mass and caused a great deal of clogging in the sludge pipe. Compressed air was found to be the best medium for clearing these blockages and a small compressor was installed which is also used for supplying air to remove scum from the settling tanks.

At the Cydna Works a similar, but smaller (14 ft. diameter), dividing tank was subsequently provided. In this tank the flow was directed downward. Here also a fair amount of settlement took place, though no trouble was encountered in drawing sludge. Turbulence at the surface was much less than that noted at the Klipspruit Works. Regarding the drawing of sludge it should be noted that a strictly domestic sewage is treated at the Cydna Works.

The dividing tank for reconditioned sludge at the Delta Works (previously mentioned) was constructed without means for withdrawing settled solids. This tank is 7 ft. 6 in. diameter and the inlet pipe discharges downward, with the end of the pipe about 23 inches above the conical bottom. This design has been very successful and no settlement has taken place.

Device for Removing Scum from Settling Tanks by Compressed Air.—Note: A complete description of this device appears in This Journal, 14, 897–901 (July, 1942).

The Hamlin Reversible Filter.—The object of this filter is to serve the dual purpose of a humus tank and sand filter. This type of filter was first built by Mr. C. H. Hamlin, Sewage Works Manager of Luton Works, England. This design was adapted because it was felt desirable to pass the humus tank effluent through sand filters, and if the two functions could be combined in a single structure considerable savings could be realized.

Individual units are each 26 ft. by 75 ft. in plan, with a total depth of 3 ft. 3 in. at the side walls. Influent is supplied through a central channel, 1 ft. 6 in. wide by 1 ft. 6 in. deep, running the length of the bed. The top of the filtering medium is at the same level as the top of this channel. Filtered effluent is collected in two channels, each 1 ft. 3 in. by 1 ft. 3 in., located adjacent to, and with their tops on a level with the bottom of, the inlet channel. These two lower channels are covered by 18 in. by 18 in. paving slabs laid with 2 in. gaps. The floor of the filter slopes 3 in. from the side walls to these channels. The filtering medium is composed of four layers, with 3 in. to 6 in. of 3 in. stone on the bottom. On this is laid 3 in. of 1 in. stone, then 3 in. of ½ in. stone, and then 6 in. of sand.

The units are operated with the water level 3 in. above the top of the sand. Valves are provided to permit drawing down the water level to medium level, or to empty the unit completely. When emptied, effluent from an adjoining filter can be passed upward through the medium, lifting the humus from the top of the sand, and flushing it into the supply channel and thence to the sludge main. As in the case of the Luton filters, provision is made for stirring the settled humus by means of squeegees hung from a transport carriage which runs in channel guides built into the walls.

Little work has been done thus far on the operation of these units as upward flow filters. The construction of the new works at Klipspruit is still in progress and certain equipment is yet to be delivered. It has been impossible thus far to operate the filters continuously and under fair conditions. It was first thought that best results would be obtained with a fairly coarse and evenly grained sand. Results seem to indicate, however, that with such a sand the humus is carried into the medium and not readily washed away when the flow is reversed. In some of the filters the coarse sand has been replaced by much finer material and considerable improvement noted.

The economic possibilities of the plant will be apparent when it is pointed out that the cost of a plant to treat one million gallons per day by means of humus tanks followed by sand filters is approximately £4,000 to £6,700, depending on whether earth or concrete walls are used for the sand filters. If the reversible filter proves successful and can treat approximately the quantities possible at the Luton Works, the above costs could be reduced to approximately £1,600.

Experimental Filters 12 Feet Deep.—Extensive experiments were carried out on two experimental trickling filters, one 6 ft. and the other 12 ft. deep for the following purposes:

a. To study the effect of depth.
b. To determine the relative merits of two filtering mediums, minestone and granite. Minestone contains a high proportion of flats and dust which is difficult to eliminate from commercial run stone. Granite is admittedly superior but costs approximately twice as much.
c. To study the relative merits of different sizes of stone.
d. To study the economics of heating filter beds.
e. To study the economics of forced ventilation.
f. To determine the dosing rate required to provide the partial purification necessary for that portion of the effluent used for irrigation.

The filters are 100 ft. in diameter, each divided into twelve equal sectors by brick on edge walls radiating from the center. A center collecting channel, sloping from the center to the perimeter, is provided at the center of each sector. The walls of the 6 ft. filter were built high enough to allow increasing the depth to 9 ft., and the walls may be increased to 12 ft. The filters were dosed from two elevated dosing tanks. The inlet to these tanks was controlled by three identical weirs, one serving the 6 ft. filter and two the 12 ft. filter. Sewage was distributed to the filters by means of two specially constructed distributors, one with six arms and the other with eight.

Details of the filters were as follows:

Sector	Filtering Medium	Other Details	
		Filter A—6 Ft.	Filter B—12 Ft.
1	1 in.–1½ in. Minestone	Forced draft through perforated pipe 2 ft. below surface	Forced draft through perforated pipe 2 ft. below surface
2	1½ in.–2 in. Minestone	Forced draft through perforated pipe 2 ft. below surface	Forced draft through perforated pipe 2 ft. below surface
3	1 in.–1½ in. Minestone	Warmed air forced through perforated pipes	Warmed air forced through perforated pipes
4	1 in.–1½ in. Minestone	Heating coils	Heating coils
5	1 in.–1½ in. Minestone	Natural ventilation zone 3 ft. down	Natural ventilation zone 6 ft. down
6	1 in.–1½ in. Minestone	Two natural ventilation zones 2 ft. and 4 ft. down	Two natural ventilation zones 4 ft. and 8 ft. down
7	1 in.–1½ in. Minestone		
8	1½ in.–2 in. Minestone		
9	2½ in.–3 in. Minestone		
10	1 in.–1½ in. Granite		
11	1 in.–1½ in. Minestone	With topping of ¾ in. stone 12 in. deep	With topping of ¾ in. stone 12 in. deep
12	1 in.–1½ in. Minestone	With topping of 3 in. stone 12 in. deep	With topping of 3 in. stone 12 in. deep

The settled sewage fed to the filters and the effluent from each sector were sampled once a week for 24 hours, taking hourly samples. These samples were, after settling, tested in the laboratory for 4 hours oxygen absorption, nitrites, and nitrates.

For purposes of graphical representation the three effluent analyses were combined into a single figure. This was done by the following mathematical expression:

$$\text{Oxidation in the effluent} = (\text{Nitrite N} \times 8/7 \times 3/2) + (\text{Nitrate N} \times 8/7 \times 5/2) - (\text{Ox. Abs. in 4 hr.} - \text{Nitrite N} \times 8/7)$$

The nitrite nitrogen figure is deducted from the oxygen absorbed figure since the latter includes the oxygen necessary to oxidize nitrite to nitrate, and nitrite is regarded as oxidation achieved and not as an impurity to be oxidized.

During the first 10 weeks the flow was held at an average of 138 gal. per cu. yd. per day on each filter. The flow was then increased each month, as follows:

Dec. 2, '40 to Jan. 2, '41, 224 gal. per cu. yd. per day
Jan. 2, '41 to Feb. 3, '41, 273 gal. per cu. yd. per day
Feb. 3, '41 to Mar. 15, '41, 303 gal. per cu. yd. per day
After March 15, '41, 357 gal. per cu. yd. per day

In regard to the 12 ft. filter the curves showed that the sectors with natural ventilation zones provided the greatest purifying effect. One ventilation zone appeared to be better than two, although the difference between the two sectors is less with higher flows. Sector No. 9 (2½ in. to 3 in.) showed better results than the average of sectors 1, 3, 4, and 7 (1 in. to 1½ in. stone), but not as good results as sectors 2 and 8 averaged (1½ in. to 2 in.). Possibly too much air, with the accompanying cooling effect, is provided by two zones and by the coarse stone.

About the same variations were noted with the 6 ft. filter. It appears that a 12 ft. filter is preferable to a 6 ft. if proper ventilation is provided.

The following table is presented to give a better view of the relative efficiencies of each sector.

Oxygen Absorbed per Cubic Yard per Day
12 ft. Filter

Date	Sectors 1, 3, 4, 7	Sectors 2, 8	Sector 5	Sector 6	Sector 9	Sector 10	Sector 11	Sector 12
12/1/40	0.066	0.13	0.23	0.21	0.098	0.11	0.13	0.10
1/2/41	0.16	0.26	0.47	0.39	0.19	0.22	0.13	0.16
2/3/41	0.089	0.22	0.36	0.23	0.14	0.20	0.19	0.11
3/7/41	0.24	0.27	0.39	0.36	0.26	0.26	0.26	0.23

Study of Flow through and Settlement of Settleable Solids in Sedimentation Tanks

Experiments at Delta.—These tests were carried out in an upward flow Dortmund type tank 25 ft. in diameter, with vertical sides 6 ft. deep. The lower conical portion, with a side slope of 60° with the horizontal, provides a total depth of 29 ft. Influent enters through a bell-mouthed outlet facing upwards inside a 6 ft. diameter stilling well. The top of the bell-mouth is 8 in. below the water surface, and the stilling well extends 9 ft. 6 in. below water level.

Samples were collected from a vertical plane at five points along different radii and at different depths at intervals of 1½ ft., starting 3 in. below the surface. Settleable solids determinations were made in Imhoff cones, allowing one-hour retention periods. Results were shown diagramatically by plotting the volumes of settled solids as the radii of circles on a cross-sectional sketch of the tank.

From these sketches it is possible to trace approximate lines of flow or lines of uniform velocity through the tank. A very gradual decrease in the size of the circles indicates a steady flow of practically constant velocity.

The following table shows the results of one test.

Flow G.P.H. (Imp.)	Depth Below Surface	0	1	2	3	4	5
		Cu. Cm. per Liter					
29,000	3 in.	—	Tr.	Tr.	Tr.	Tr.	Tr.
29,000	1 ft. 9 in.	—	3.8	2.2	1.1	1.0	1.0
36,000	3 ft. 3 in.	—	7.7	5.0	6.0	6.1	2.1
30,000	4 ft. 9 in.	—	5.1	5.0	6.5	7.2	9.8
29,000	6 ft. 3 in.	—	4.2	8.4	8.4	7.5	6.4
29,000	7 ft. 9 in.	17.0	6.1	8.0	5.5	6.9	—
31,000	9 ft. 3 in.	16.2	8.3	4.1	4.6	5.8	—
40,000	10 ft. 9 in.	14.5	12.0	7.8	5.0	7.0	—
22,000	12 ft. 3 in.	8.0	3.9	4.2	2.0	—	—
22,000	13 ft. 9 in.	5.5	4.3	4.7	3.1	—	—
25,000	15 ft. 3 in.	13.0	8.0	6.8	7.0	—	—
—	16 ft. 9 in.	22.0	14.0	15.0	—	—	—

In the above table point "0" is below the stilling well, approximately 2 ft. from the center of the tank, and point 5 is between the scum baffle and the weir. Desludging of the tank was started five minutes before the sampling at the 12 ft. 3 in. depth. (The volume of the tank is approximately 41,600 Imperial gallons, allowing about 8 ft. in the bottom of the cone for sludge volume.)

From a study of all results it was concluded that an improvement could be made by placing one or two concentric draw-off channels between the existing weir and the stilling well. This would increase the vertical component of flow and would prevent the strong radial flow found to exist at the 1 ft. 9 in. depth.

Experiments on the New Primary Settling Tank at Bruma.—This tank has four cone shaped hoppers each 21 ft. 6 in. diameter placed symmetrically about an 18 in. supply pipe, forming a square tank with rounded corners. The maximum water depth is 23 ft. 7½ in. The stilling well is 10 ft. in diameter and extends 3 ft. 7 in. below the surface. The volume of the tank, excluding a sludge allowance of 6 ft. 10½ in. in each hopper is 128,142 Imp. gallons. Thus a detention period of 2.47 hours is obtained with an average peak flow of 52,000 Imperial g.p.hr. This figure is high as one hour detention at peak flows is usually used for design of primary settling tanks.

Tests similar to those at the Delta plant were carried on, and in addition fluorescein dye tests and special sampling around the periphery of the tank were carried on. The dye tests indicated short circuiting along the horizontal axes of the tank above the interpenetration curves of the cones.

Samples at various depths were collected from vertical planes across the diagonal and along the axes of the tank. Results indicated very satisfactory flow conditions along the diagonals. Samples collected in the plane along the axes of the tank indicated that an improvement could be made by placing effluent channels along these axes above the interpenetration curves of the cones. This is being done in a new tank being built. For the purpose of inducing a more pronounced vertical flow a 14 ft. stilling well extending to a depth of 5 ft. 3 in. will be provided.

T. L. Herrick

SEWAGE TREATMENT FOR THE R.C.A.F. BY TRICKLING FILTERS

By G. Graham Reid

Water and Sewage (Toronto), 80, 29 (Nov., 1942)

A design has been adopted for the R.C.A.F. which combines the merits of both the bio-filter and the aero-filter to some extent. The efficiency may be increased by the addition of forced draft air or by the regulation, within certain limits, of the recirculation flow.

The design follows the single stage bio-filter system with the further provision that the recirculated effluent may be varied, and that it may be taken off prior to or following the secondary settling tank, and may be discharged either into the primary settling tank or directly into the syphon chamber.

The detention period at peak flows has been set at two and three hours for the primary and secondary tanks, respectively, without the recirculated flow.

The filter has been designed for a rate of 6–9 m.g.a.d. A stone depth of 5 ft. has been used rather than the 3 ft. recommended for the bio-filtration system. Filters have been designed in duplicate so that either of them may be used for periods as an intermittent filter, while the other is used as a high rate filter.

T. L. Herrick

OPERATING RESULTS AT THE NORTH TORONTO SEWAGE TREATMENT PLANT

By Norman G. McDonald

Water and Sewage (Toronto), 80, 32 (Nov., 1942)

The North Toronto plant serves the area known as North Toronto, and some suburban areas. Until a few years ago the area served was strictly residential, with a great many persons spending the working hours downtown. In the last few years, however, there has been a large industrial growth in the town of Leaside which draws workers from other parts of the city, so that the plant now serves a larger population.

The territory is sewered on the combined plan. The plant, activated sludge type, consists of mechanically cleaned bar screens, grit chambers, primary settling tanks, aeration tanks, final settling tanks, heated digestion tanks, and glass-covered sludge drying beds. A sedimentation tank for treating storm flows in excess of twice the dry weather flow is also provided. The original plant, built in 1928, was designed for 50,000 population and a flow of 5 million Imperial gallons daily containing 167 p.p.m. suspended solids. The enlarged plant, placed in operation late in 1934, was designed for 100,000 and a flow of 7.5 m.g.d. and 200 p.p.m. suspended solids and 200 p.p.m. 5-day B.O.D. Although the enlarged plant has been in operation for less than 8 years it is already loaded to about its rated capacity for flow and population. The B.O.D. and suspended solids loads are now respectively 135 and 167 per cent of the designed load. The following table shows data relative to plant loadings.

Year	Resident Population	Flow M.G.D.	Suspended Solids		B.O.D.	
			P.P.M.	Per Cent of Design Capacity	P.P.M.	Per Cent of Design Capacity
1932	65,018	4.290	214	110	193	99
1933	68,337	4.303	195	101	192	99
1934	71,218	4.129	185	92	185	92
1935	72,911	5.029	238	79	247	82
1936	75,670	5.445	239	87	249	90
1937	79,900	6.000	218	87	243	97
1938	82,177	5.600	262	98	255	95
1939	86,122	6.025	285	115	262	105
1940	88,745	6.430	280	120	290	124
1941	92,121	6.693	310	138	280	125
1942*	—	7.407	338	167	273	135

* 9 months.

The primary settling tanks provide a detention period of 2 hours at rated average flow. Excess activated sludge and digestion tank supernatant liquor are discharged to the channel ahead of the tanks.

The aeration tanks, spiral flow type, are 8 in number and have a 10.5 ft. depth of water. They provide a detention period of 4¾ hours at average flow and 40 per cent return sludge. The 5 final settling tanks provide a detention period of 3 hours and an overflow rate of 960 gal. per sq. ft. per day. Up to the present time it has not been necessary to use all of the tanks; for long periods only 3 have been used. The following table presents data on the results of operation of the aeration system.

Year	Air, Cu. Ft. per Gal. (Imp.)	B.O.D. Removed Lb. per 1000 Cu. Ft. of Air		Per Cent Return Sludge	Mixed Liquor P.P.M.	Per Cent Removal	
		In Plant	In Secondary Treatment			Susp. Solids	B.O.D.
1932	1.05	1.52	1.15	19	3,300	76.7	82.7
1933	1.14	1.23	1.02	21	2,860	70.8	72.7
1934	1.15	1.14	1.04	22	2,672	75.5	70.9
1935	1.08	2.07	1.43	31	3,190	93.7	90.7
1936	1.15	2.02	1.60	23	2,740	96.6	94.3
1937	1.16	1.95	1.72	21	2,340	95.9	93.0
1938	1.22	1.97	1.61	19	2,410	96.6	94.1
1939	1.17	2.11	1.63	23	2,670	96.8	94.0
1940	1.10	2.50	1.94	30	2,910	97.5	94.8
1941	1.05	2.54	1.77	18	1,800	96.5	95.0
1942	1.01	2.71	2.06	20	2,420	95.2	94.3

Digestion of waste sludge is carried on in two stages, using four tanks with a combined capacity of 208,000 cu. ft. for the first stage, and the four original tanks with a capacity of 104,000 cu. ft. in the second stage. The total capacity of 312,000 is based on 3.12 cu. ft. per capita. The tanks are heated by means of hot water coils operated at a maximum temperature of 120° F. Two storage tanks with a combined capacity of 104,000 cu. ft. are also provided. The gas is used for generating steam which is utilized for heating the plant, including the glass covered drying beds, and heating the digestion tanks. During cold weather the gas is supplemented by fuel oil.

During 1939, 1940 and 1941 the average gas production per pound of volatile solids removed by the plant was 9.25 cu. ft. The production per pound of solids actually destroyed in the tanks was approximately 21.6 pounds. Other data on the digestion of sludge are shown below.

Year	Loading, Pounds Suspended Solids per Cu. Ft. per Month	Digested Sludge Per Cent Volatile	Gas Produced per Day	
			Cu. Ft.	Cu. Ft. per Capita
1932	1.83	47.3	51,000	0.78
1933	1.54	56.4	61,300	0.90
1934	1.50	60.5	66,000	0.93
1935	0.97	51.7	104,900	1.44
1936	1.09	54.2	112,600	1.49
1937	1.08	51.8	109,500	1.37
1938	1.22	53.5	127,000	1.55
1939	1.45	52.0	127,000	1.48
1940	1.53	54.8	131,000	1.48
1941	1.73	50.7	147,000	1.60
1942*	2.06	50.5	140,000	—

* 9 months.

The area of the glass covered sludge drying beds is 60,000 sq. ft., which is 0.6 sq. ft. per capita on the designed basis. Dried sludge is removed from the beds by hand.

With a solids removal of over 95 per cent in this plant the sludge contains so much extremely fine matter that it is jelly-like in character and retains the water when applied to the beds. Alum added at the rate of about 10 per cent of the dry solids in the digested sludge gives a drying rate of approximately 4 lb. of dry solids per sq. ft. per month. The capacity of the beds in winter is far below that obtained in summer, and operation of the storage tanks has been found necessary. Fans are used to circulate the air over the beds.

T. L. Herrick

SLUDGE DIGESTION AT YORK

By H. C. Whitehead

The Surveyor, 101, 388 (November 13, 1942)

Selection of heated or unheated digestion tanks depends upon whether or not it is profitable to collect the gas and utilize it for power and heating purposes. Digestion can be carried out with equal success in heated or unheated tanks and the cost for both methods is approximately the same. In the latter case (unheated tanks) the tank capacity is usually twice that of tanks in which the sludge is heated to 70 or 80 degrees.

At York the present power demands were not large enough to warrant installation of tank heating devices.

Digestion is best carried out in 2 stages. In the first, or primary stage, 90 per cent of the digestion takes place. The second stage is necessary to condition the sludge for rapid drying in open air. In the second stage a physical change takes place in the "water bound" condition of the sludge which enables the sludge to free itself quickly of surplus water.

K. V. Hill

EXTENSIONS TO YORK SEWAGE DISPOSAL WORKS

By Donald Parker

The Surveyor, 101, 387–388 (November 13, 1942)

The original works at York were constructed between 1890 and 1896, at which time the population was approximately 70,000 and the dry-weather flow about 2 m.g.d. All sewage was, and still is, collected at the main pumping station and pumped 2 miles through a 27-inch diameter cast iron pipe to the sewage treatment works.

At the sewage treatment works lime and alum were added and the sewage then settled in six sedimentation tanks having a total capacity of 1,500,000 gallons. Effluent passed directly to the river: sludge removed was pressed and put upon the land.

In 1900 and 1903 two experimental bacterial beds were constructed and used continuously until 1939.

In 1912 and 1914 two detritus tanks and two sedimentation tanks were added increasing the total sedimentation capacity to 2,500,000 gallons. Ten bacterial beds were also constructed, each 102 ft. in diameter and 6 ft. deep and humus tanks having a total capacity of 54,000 gallons. Sludge pressing was abandoned and sludge lagoons constructed. At the pumping station mechanical screens were installed and a detritus tank and two sedimentation tanks each of 500,000 gallons capacity were constructed to provide preliminary treatment for storm water before discharging it to the river.

In 1921 and 1928 five new bacterial beds were added to the plant.

In 1936 it became apparent that further additions were required and Mr. H. C. Whitehead was retained to study and report on the matter. He recommended additional pumping capacity, filters, and humus tanks, additional storm water tanks and sludge disposal by digestion instead of lagooning.

The new extensions are designed for a population of 120,000 and an estimated dry-weather flow of 5,280,000 gallons. The maximum quantity to be given complete treatment is 12,000,000 gallons per day.

The bacterial filters have been increased by a new rectangular filter 700 ft. long by 150 ft. wide, constructed on the site of the old lagoons. The filter is 6 ft. deep. Sewage is applied to the filter by rope-hauled distributors.

Four additional humus tanks have been constructed. They are 65 ft. long, 60 ft. wide, and 4 ft. deep. Tank bottoms are sloped 6 in. to a center sludge channel. Humus is pumped back to the raw sewage. There are three 300 G.P.M. humus pumps.

Five primary and five secondary digestion tanks have been constructed, each 60 ft. in diameter, 22 ft. side depth, and 24 ft. center depth. Total tank capacity provides 5 cu. ft. per capita. The tanks are of reinforced concrete and backfilled with earth to within 3 ft. of the top. No heating is provided now but provision is made for possible future installation of mixing devices, heating coils, and gas collection.

Twenty-five thousand sq. yd. of sludge drying beds have been provided, equivalent to 0.21 sq. yd. per person. The beds are drained by 6-in. drains laid diagonally at 15 ft. centers. The drains are covered by 12 in. of ashes, the top 6 in. of which have been screened to pass through a ½-in. square mesh. Water draw-offs are provided in each corner of the beds and the drawn off water pumped back to the inlet to the sedimentation tanks.

The article does not state whether or not lime and alum treatment is still practiced. Nor does the article state that additional land was required for new structures.

K. V. Hill

PRACTICAL DIFFICULTIES OF RIVER POLLUTION PREVENTION

The Surveyor, 101, 407–408 (November 27, 1942)

A paper on the above subject by A. Seaton was printed in the *Surveyor,* October 23, 1942.* The following are excerpts from discussions of the paper by members of the Institute.

Dr. H. Clay agreed with Mr. Seaton that pollution from storm water overflows was often due to the inadequacy of old sewerage systems to carry flows greatly in excess of those for which they were designed. He felt Mr. Seaton was overly optimistic on the beneficial effect of the Drainage of Trade Premises Act upon rivers pollution.

Mr. F. Wrigley said many schemes of sewage disposal had been consummated because of power given to county councils and rural district councils to help financially parishes within country districts. He stated that 28 out of 39 collieries in his district carried out coal washing: of these 17 had provided flocculation, clarification or filter plants. At 11 other pits settling tanks or lagoons had been provided. He paid tribute to Army and Air Force authorities for cooperation with local authorities to prevent pollution of rivers, streams, and ground water.

Dr. S. H. Jenkins in citing the Royal Commission standard of dilution of eight volumes of river water to one of effluent said that most rivers could provide this dilution. It would, however, be difficult and costly for many works in industrial areas to produce effluents which would not create a B.O.D. in the rivers of more than 4 parts per million. He also mentioned the difficulty in providing adequate storm water treatment and gave one example of an effluent from storm water tanks equal in size to nine hours' dry weather flow, as having 88 p.p.m. suspended matter, 65 p.p.m oxygen absorbed and 117 p.p.m. biochemical oxygen demand.

Mr. John Hurley said that much effective action against stream pollution under the Drainage of Trade Premises Act was lost due to the fact that prescriptive rights of discharge (by a trader) were retained under the Act and that corrective legislation should be introduced after the war. Except for oil pollution, he felt the country had gone through the first three years of the war without very serious river pollution.

Mr. C. B. O. Jones described a method of ridding scrubber water of sulfuretted hydrogen before discharge to a stream. Three hours' aeration with compressed air at 2 lb. per sq. in. pressure removed 32.4 of 32.5 p.p.m. of hydrogen sulfide and made possible the reuse of the effluent for scrubber work. He also stated that in a few cases involving cyanide wastes, almost complete precipitation of ferro-cyanide was obtained by the addition of ferrous sulfate. In discussing disposition of metal cuttings, he cited the regulation of the Ministry of Supply that they be ground and freed of oil. The cuttings in one case were freed of oil by spraying with live steam while in a rotating cylinder set at an angle. The oily emulsion drained to a sump into which 1 lb. of salt to each 40 gal. of material was added and mixed with a steam blast. After settlement for 12 hours the oil was drawn off and used as fuel with coal slack. The water was discharged to a sewer.

Mr. W. Fitzpatrick said that one square yard of sludge drying bed area per five persons was inadequate. He suggested that 2 square yards per person would be nearer the figure.

Mr. S. McNicholas endorsed Mr. Fitzpatrick's remarks regarding sludge drying bed area.

K. V. Hill

* Abstract published in Sewage Works Journal, 15, 161 (January, 1943).

SEWAGE PURIFICATION SERVICES IN RELATION TO NATIONAL POST-WAR PLANNING

The Surveyor 101, 417–418 (December 4, 1942)

The Institute of Sewage Purification have considered the above subject and prepared a memorandum for submission to the Minister of Works and Planning, the Minister of Health, the Minister of Agriculture and Fisheries and others concerned with sewage purification and rivers conservancy. The following items are abstracted from the memorandum.

Lack of Co-operation between Authorities.—The Institute believes that lack of co-operation between authorities is responsible for inefficiencies, uneconomical conditions, and perhaps some poorly operated sewage treatment plants. Lack of co-operation is responsible for the existence of many small plants, some of them being so small that economical operation is impracticable. There has also been unnecessary multiplication of works due to lack of co-operation between authorities. Many local authorities regard expenditures for sewage disposal as a necessary evil and money for this service is grudgingly appropriated. In such cases results may be poor and will nullify the good results secured by other authorities. Smaller undertakings may not be able to afford competent operators.

A greater measure of co-ordination with other public services is desirable, such as those dealing with surface water drainage, industrial undertakings and trade wastes, Rivers Conservancy and Fishery Boards.

Many authorities have special problems which are beyond their own resources to solve; such problems could more readily be solved by an organization. Promotion of the use of sewage sludge as fertilizer could be handled more readily than it now is by greater organization.

Planning on a Regional Basis.—The Institute believes that the service of sewage disposal can be handled efficiently and economically by planning on a regional basis. It believes that in the future the township should cease to be the unit of area for administrative control, and that the unit should preferably be the natural drainage area of a river or a major tributary of a river.

The interest of sewage purification authorities and water suppliers are mutual. The cost of either service should not be needlessly increased by the failure of any other service to carry out its work efficiently.

Under the Drainage of Trade Premises Act the trader has the right to discharge trade effluent into the sewers. In some cases this might work hardships on the ratepayers which could be avoided by co-operation with the sewage authority. Trade effluents may also contain constituents of commercial value or it might be possible to treat them cheaper at a sewage works than on the trade premises. Joint committees of trade organizations and sewage purification authorities could aid in such matters.

There is need for co-operation with river conservancy authorities to fix suitable standards for sewage effluents to meet the requirements of the river and the use to which the water will be put.

The Institute suggests the desirability of putting discharge of storm water also under the jurisdiction of regional sewage authorities.

Works Design, Construction and Operation.—The Institute states its belief that the design, construction and operation of all publicly owned sewage treatment works should be under the direction of regional authorities who in turn would be responsible to the appropriate rivers conservancy authority. Such regional authorities should be possessed of full powers for the shaping of local policy and the execution of works, subject only to general direction by a central authority.

The regional authority should also be responsible for design and construction of intercepting sewers and control of trade wastes discharged to public sewers.

Advantages of Regionalization.—The following paragraphs are quoted verbatim from the Institute's memorandum.

"(a) The regional authority would be able to draw up a long-term program or work; and to employ a competent staff of trained personnel, capable of administering the service on a wide and comprehensive basis.

(b) There would be closer co-operation between those responsible for design and those responsible for operation.

(c) Small plants would be supervised as adequately and effectually as large ones, and the wider experience of the staff would enable these smaller works to be made to function to the best advantage.

(d) The position which now often obtains whereby the good work of one authority in the purification of its sewage is nullified by the failure of its neighbor to carry out its obligations would be avoided.

(e) Variations in the cost of sewage treatment would tend to be evened out.

(f) Similar regulations for the admission of industrial wastes to sewers would prevail over a wide area, and any advantage associated with large sewerage schemes, such as the balancing effect on flows, and the equalization of industrial wastes, could be utilized.

(g) A comprehensive policy in regard to research could be laid down and carried out by the regional authorities, in collaboration with the central authority.

(h) The work of the rivers conservancy authority would be facilitated in that it would deal with fewer sewage purification authorities.

(i) There would be close co-operation with other water users, and the costly promotion of, and opposition to, Parliamentary Bills would be very largely eliminated.

(j) Regionalization would materially assist in the utilization of sludge for agriculture by making practicable the setting up of a centralized marketing and distributing organization."

K. V. Hill

DISSOLVED OXYGEN RECORDINGS WITH THE DROPPING MERCURY ELECTRODE

By Robert S. Ingols

Industrial and Engineering Chemistry (Anal. Ed.), 14, 3, 256–258 (March 15, 1942)

The instrument used in these experiments employs a simple potentiometer circuit with a sensitive, suspension, mirror galvanometer to measure the current flow in the dropping mercury electrode circuit. A light beam impinging on the mirror is reflected to a photoelectric cell. The current from the photoelectric cell is amplified and then recorded at minute intervals with a recording thread galvanometer. The electrodes consist of a calomel half cell reference electrode and the dropping mercury electrode. Variations in dissolved oxygen produce changes in the current flow. Studies with this apparatus demonstrated that the shape of the vessel containing the aerated sludge mixture largely determines the efficiency of the gas used for aeration. The effect upon dissolved oxygen of the addition of different quantities of the same food to activated sludge indicates that when more food is added there is no effect upon the dissolved oxygen unless or until the enzyme capacity is large enough to handle the increased load.

Dissolved oxygen level variations in the aeration tanks of an activated sludge plant were studied by placing the electrodes at various points in tanks. Charts showing the recorded values are presented. Five references.

Paul D. Haney

PHOSPHINE AND SLUDGE DIGESTION

By Willem Rudolfs and Glenn W. Stahl

Industrial and Engineering Chemistry, **34,** 8, 982–984 (August, 1942)

A survey of the literature indicated that the production of phosphine (PH_3) and the spontaneously inflammable hydrogen hemiphosphide $(PH_2)_2$ through the bacterial reduction of phosphorous compounds is an open question. Production of such phosphorus compounds in digesters is of practical, as well as theoretical, interest since their presence might explain several digester explosions. The possible production of phosphine during digestion was studied by the addition of various phosphorus compounds to digesting sludge mixtures. In every case a qualitative test for phosphine in the sludge gas was obtained, but this could not be confirmed by quantitative methods. The report that digester gas may contain 0.06 per cent phosphine was not confirmed.

Based on the assumption that phosphine was actually present, the authors conclude that 0.0001 per cent is probably the upper limit of the phosphine content of digester gas.

Thirteen references.

Paul D. Haney

UTILIZATION OF PICKLE LIQUOR

By F. J. Van Antwerpen

Industrial and Engineering Chemistry, **34,** 10, 1138–1141 (October, 1942)

Increased steel production has intensified the ever present problem of the disposal of waste pickle liquor. If no positive program for dealing with this waste is developed serious damage may result in many streams. Although most of the acid load in the rivers is derived from coal mine drainage, pickle liquor contributes a significant portion of the total. Experiments have been conducted on the treatment of pickle liquor for the recovery of substances suitable for building material. This material, known as Ferron, is now being manufactured on a limited commercial scale at one steel plant. About 25 tons of pickle liquor are processed each day at this plant. The Ferron process involves addition of a filler and then neutralization of the pickle liquor with lime followed by filtration or pressing of the precipitated iron (principally ferrous) hydroxide, calcium sulfate and filler.

The process is varied according to the product desired. The waste from the Ferron plant itself is said to be satisfactory for disposal into streams or sewers. The pH is high (about 11) and all iron and other heavy metals have been precipitated.

A plant capable of treating 25 tons per day of pickle liquor costs $40,000 per year. This corresponds to about $4.50 per ton of pickle liquor or about $9.00 per ton of Ferron produced. A ton of Ferron represents about 500 gallons of pickle liquor.

Paul D. Haney

EFFECT OF RIVER MUD DEPOSITS ON DETERMINATION OF B.O.D. OF SUPERNATANT LIQUOR

By W. Allan Moore and C. C. Ruchhoft

Industrial and Engineering Chemistry, **14,** 933 (Dec., 1942)

During an investigation of the Illinois River, Ruchhoft and Moore noted that the B.O.D. results varied widely at certain points depending on whether the initial D.O. was calculated or actually determined. The values obtained by actual determination ranged from 60 per cent to 30 per cent lower than those obtained by calculation of the initial D.O. This they attributed to the presence of river mud and noted that the discrepancy was lower at points at which the mud had become more stabilized. Table I shows B.O.D. results obtained at two points on the river approximately eleven miles apart.

TABLE I.—*Discrepancy in B.O.D. Results Obtained by Two Different Methods on Illinois Waterway*

Station 1		Station 2	
Average Determined Initial	Average Calculated Initial	Average Determined Initial	Average Calculated Initial
11.9[a]	22.0[a]	7.3[b]	10.4[b]

[a] 13 results. [b] 6 results.

Further experiments using fresh domestic sewage which had been allowed to stand under anaerobic conditions for varying periods of time indicated that the mere existence of anaerobic conditions in diluted sewage is not an important factor contributing to the B.O.D. discrepancies found on the Illinois River. The results were obtained (1) by calculations of the initial D.O. from the D.O. content of the dilution water and per cent concentration of sewage and (2) by direct determination using the Winkler method after vigorous aeration of the properly diluted sample. Except in the case of the 48 hour sample of undiluted sewage, the results checked well within the limits of error.

The effect of mud deposits on the B.O.D. of the supernatant was next determined.

The results indicated that a well stabilized mud, that is one having a low B.O.D. value, had little or no effect on the B.O.D. of the supernatant. However with strong muds (high B.O.D.) discrepancies were found which increased with the length of time the sample was anaerobic. The magnitude of these discrepancies increased in mixtures of weak supernatant and strong mud.

In the anaerobic decomposition of river muds, compounds are formed, some of which have high reducing values. Experiments designed to correlate, if possible, the oxidation-reduction potential of the supernatant liquor and D.O. values as determined by the Winkler method indicated the discrepancies noted could not be accounted for on the basis of the oxidation-reduction potential developed in the supernatant liquor.

On the basis of these experiments it was concluded that in the determination of the B.O.D. of river water containing quantities of unstabilized or slightly stabilized organic matter, the initial D.O. of the incubated sample should be calculated and not actually determined by the Winkler method. This procedure gives the B.O.D. of the liquor plus the oxygen demand of the products of decomposition of the river mud which have diffused into the supernatant.

The experiments indicated that the decomposition products of an anaerobic river mud which diffuse into an anaerobic supernatant undergo rapid chemical oxidation when the supernatant was aerated. They also indicated that the B.O.D. of an anaerobic river sample obtained after initial determination of D.O. is the B.O.D. of the supernatant water only. The discrepancy between results obtained by the two methods represents the oxygen requirement contribution of the river mud deposit which was satisfied upon re-aeration of the anaerobic supernatant. The two methods used simultaneously would indicate sections of a polluted stream in which slightly stabilized mud deposits contribute to the total B.O.D.

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Eagle, George H. Ohio (Alt.).
Early, Fred J., Jr. California.
Easdale, W. C. England (I. S. E.).
Eastburn, W. H. Pennsylvania.
Eastman, T. F. California.
Eckelcamp, Joseph. Michigan (Alt.).
Eddy, Harrison P., Jr. New England.
Edge, L. C. Georgia.
Edgecombe, G. H. Canada.
Edgerley, Edward. Pennsylvania.
Edighoffer, Albert. New York.
Edinger, Harry F. New York.
Edmond, H. P. Georgia.
Edmondson, J. H. England (I. S. P.).
Edwards, Gail P. New York.
Edwards, R. E. Ohio.
Edwards, William L. New York.
Egan, J. H. California.
Eglof, Dr. Warren K. New York.
Ehle, Virgil. New York.
Ehlers, Ralph B. Michigan, New England.
Eich, Henry F. New York.
Eidsness, Fred A. Florida.
Eldridge, E. F. Michigan.
Electro Rust-Proofing Co. Associate.
Elgin, Sanitary District of. (Corporate) Central States.
Elnor, Geo. E. Canada.
Elias, George A. Pennsylvania.
Eliassen, Rolf. New York.
Ellinger, Morris. California (Alt.).
Elliot, William H., Jr. New England.
Ellis, Albert. Central States.
Ellms, J. W. Ohio.
Ellsworth, Samuel M. New England.
Ellsworth, William M., Jr. Maryland-Delaware.
Elsdon, Dr. G. D. England (I. S. P.).
Ely, E. H. England (I. S. E.).
Emerson, C. A. Honorary, Pennsylvania.
Emigh, William C. Pennsylvania.
Engineering News-Record. Associate.
Enloe, V. P. Georgia.
Enslow, L. H. New York.
Epler, J. E. Central States.
Epstein, Harold. New York.
Erickson, Carl V. Central States.
Erickson, Frederick K. Pacific Northwest.
Erickson, W. J. New York.
Etheridge, W. England (I. S. P.).
Ettinger, M. B. Federal.
Euler, Louis M. Maryland-Delaware.
Eustance, Arthur W. New York.
Eustance, Harry W. New York.
Evans, David A. Pennsylvania, New York.
Evans, F. M. New Jersey.
Evans, R. W. Central States.
Evans, S. C. England (I. S. P.).
Everson, R. B. Central States.

Faber, Harry A. New York, Pennsylvania.
Faccinia, Frank. California (Alt.).
Fair, Gordon M. New England (New York—Dual).
Fales, A. L. New England, Pennsylvania.
Falk, Lloyd R. New Jersey.
Falsey & Bestoff, Inc. New Jersey.
Farnsworth, G. L., Jr. Central States.
Farrant, James. New Jersey.
Farrar, J. H. California.
Farrell, Michael. New York.
Fassnacht, George G. Central States.
Faulkner, T. G. England (I. S. E.).
Fawls, James F. New York.
Feltz, Fred C. Central States.
Fenger, J. W. New York.
Fenn, Ernest G. New England.
Fenton, John V. New York.
Ferebee, James L. Central States.
Ferguson, G. H. Canada.
Ferguson, Gerald W. Florida.
Ferris, James E. (New York—Dual) New England.

Field, W. T. New York.
Filkins, D. A. Michigan (Alt.).
Finch, J. England (I. S. P.).
Finch, Lewis S. Central States.
Finch, R. M. Central States.
Finck, G. E. Maryland-Delaware.
Findlay, Arthur. New York.
Finkbeiner, Carleton S. Ohio.
Fischer, Anthony J. New York.
Fischer, F. P. Ohio.
Fishbeck, Kenneth. Michigan.
Fisher, Lawrence M. Federal.
Fisher, Wayne E. Central States.
Fitch, T. A. California.
Fitzgerald, J. A. New York.
Fitzgibbons, F. C. Central States.
FitzSimons, R. H. New York.
Five, Helge. New York.
Fiveash, Charles E. Florida.
Flanagan, Jr., Joseph E. Pennsylvania.
Flatt, F. L. Central States.
Fleet, Gerald A. New York.
Fleming, M. C. Pennsylvania.
Fleming, Paul V. New England.
Flexible Sewer-Rod Equipt. Co. Associate.
Flood, Frank L. New England.
Flower, G. E. Ohio.
Flowers, E. England (I. S. P.).
Foley, William M. New York.
Fontenelli, Louis. New Jersey.
Foote, Kenneth E. New England.
Forbes, Albert F. New York.
Ford, Robert. Central States.
Foreman, Merle S. California (Alt.).
Forsbeck, C. D. Pacific Northwest.
Forsberg, Ole. Central States.
Fort, Edwin J. New York.
Fort Dodge, City of. Iowa.
Fortenbaugh, J. Warren. New York.
Forton, R. G. Michigan.
Fosner, Dr. L. E. Rocky Mountain.
Foster, Herbert B., Jr. California.
Foster, Norman. Pennsylvania.
Foster, Richard G. Michigan.
Foster, William Floyd. California.
Foth, Herbert I. Central States.
Fowler, G. J. England (I. S. P.).
Fowler, H. D. Pacific Northwest.
Fowler, James Henry. Arizona.
Fox, Paul S. Rocky Mountain.
Foxboro Company. Associate.
Francis, Geo. W. Michigan.
Francis Hankin & Company, Ltd. Canada.
Franklin, W. M. North Carolina.
Franks, John T. Rocky Mountain.
Franzozo, Anthony. New Jersey.
Fraschina, Keeno. California.
Fraser, Charles E. Canada.
Fraters, E. W. California.
Frazier, Leonard H. New York.
Frazier, R. W. Central States.
Freeborn, W. F. England (I. S. P.).
Freeburn, H. M. Pennsylvania.
Freeland, B. H. Central States.
Freeman, A. B. Federal.
Freeman, W. B. Rocky Mountain.
French, R. Del. Canada.
Freund, J. P. Pennsylvania.
Frick, A. L., Jr. California.
Frick, Edward J. Ohio.
Frickstad, Walter N. California.
Friel, F. S. Pennsylvania.
Frith, Gilbert R. Georgia.
Froehde, F. C. California (Alt.).
Fuchs, Abraham W. Federal.
Fuhrman, Ralph E. Federal.
Fuller, H. L. Missouri.
Fuller, N. M. New York.
Fuller, Raymond H. Ohio.
Fulmer, Frank E. Central States.
Funk, John B. Maryland-Delaware.
Furphy, H. G. England (I. S. P.).

Gadomski, Albert J. New Jersey.
Gail, A. L. Central States.
Gale Oil Separator Co. Associate.
Gard, Chas. M. New York.
Gardner, George W. New York.
Gardner, R. T. California.
Garland, Chesley F. Florida.
Garner, J. H. England (I. S. P.).
Garrett, R. W. Canada.
Garthe, E. C. Federal.
Gates, Justin F. New York.
Gauntt, W. C. Texas.
Gavett, Weston. New York.
Gearhart, John C. Pacific Northwest.
Gearhart, J. N. Pacific Northwest.
Gehm, Harry Willard. New Jersey.
Gelbke, Arthur W. New York.
Gelston, W. R. Central States.
General Chemical Co. Associate.
General Electric Co. Associate.
Genter, Albert L. Maryland-Delaware.
Gentsch, Edward. Michigan.
Gerard, F. A. Central States.
Gerdel, W. E. Ohio.
Gere, William S. New York.
Geyer, John C. Maryland-Delaware.
Gibbing, Frank B. Michigan (Alt.).
Gibbons, E. V. Canada.
Gibbons, M. M. New Jersey.
Gibbs, Frederick S. New England.
Gibbs, R. C. England (I. S. P.).

Gibeau, H. A. Canada.
Gidley, H. K. Pennsylvania.
Giesey, J. K. Central States.
Gifford, J. B. Central States.
Gilbert, A. J. Arizona.
Gilbert, J. J. Pennsylvania.
Gilbert, J. Niles. Florida.
Gilcreas, F. W. New England (New York—Dual).
Gilcrest, R. V. Central States.
Giles, J. Henry. New England.
Gilkey, A. E. California (Alt.).
Gill, J. Francis. New York.
Gill, Paul. Pennsylvania.
Gillard, J. E. England (I. S. P.).
Gillespie, C. G. California.
Gillespie, Wylie W. Florida.
Gilman, Floyd. New York.
Gisborne, Frank R. New England (Alt.).
Glace, I. M., Jr. Pennsylvania (New York—Dual).
Glace, I. M. Pennsylvania.
Gladding, Charles. California.
Gladue, Donat J. New England.
Glamorgan Pipe & Foundry Co. Associate.
Glynn, William J. New York.
Goff, James S. New England.
Goff, William A. Pennsylvania.
Goicoechea, Leandro de. Florida.
Goldenberg, Charles N. Rocky Mountain.
Goldsmith, Philip. New York.
Goldthorpe, H. H. England (I. S. P.).
Golly, M. R. Central States.
Gooch, E. W. Pacific Northwest.
Goodenough, Frank H. New York.
Goodman, Arnold H. Central States.
Goodnight, V. L. Pacific Northwest.
Goodrich, Fletcher. Michigan (Alt.).
Goodridge, Harry. California.
Goodwin, S. E. Canada.
Gordon, Arthur. Central States.
Gordon, J. B. Federal.
Gorman, Richard C., Jr. New York.
Gotaas, Harold B. North Carolina.
Goudey, R. F. California.
Gould, Richard H. New York.
Grabbe Construction Co., H. A. Central States.
Gracenin, Sylvester. Pennsylvania.
Graemiger, Joseph A. New England.
Graham, James E. Michigan.
Gran, Dr. John E. Georgia.
Grant, A. J. California (Alt.).
Grantham, G. R. Central States.
Graser, William. Michigan.
Graul, Leroy H. New Jersey.
Gray, D. M. Ohio.
Gray, Harold F. California.
Greek, Edward B. Central States.
Greeley, Richard F. New England.
Greeley, Samuel A. Central States.
Green, Alvin W. Pacific Northwest.
Green, Carl E. Pacific Northwest.
Green, Howard R. Iowa.
Green, R. A. Michigan.
Greendale, Village of. Central States.
Greenleaf, John W., Jr. New England.
Gregory, L. L. England (I. S. E.).
Gregory Sanitary & Municipal Reference Library. California.
Gregory, Ted R. California.
Greig, John M. M. New York.
Grelick, David. New York.
Griffen, F. T. New York.
Griffin, A. E. New Jersey.
Griffin, Guy E. New England.
Grisham, Charles. Kansas.
Gross, Carl D. Central States.
Gross, Dwight D. Rocky Mountain.
Grossart, L. J. H. Pennsylvania.
Grosshans, Edward W. Central States.
Grover, Robert H. New York.
Growdon, Howard C. Ohio.
Gruendler Crusher & Pulverizer Co. Associate.
Gruss, A. W. California.
Gustafson, Ivar. Michigan.
Gwin, Thomas. California.
Gyatt, W. P. New York.

Haberer, John C. New York.
Habermehl, C. A. Michigan.
Haddock, Fred R. Pennsylvania.
Haemmerlein, Victor E. New York.
Hager, Fred. Central States.
Hagerty, L. T. Ohio.
Hagestad, Herman T. Central States.
Hale, Arnold H. New York.
Halff, Albert H. Central States.
Hall, Frank H. New York.
Hall, Fred B. New York.
Hall, G. Albro. Ohio.
Hall, G. D. Pacific Northwest.
Hall, Harry R. Maryland.
Hall, Howell C. Central States.
Hall, M. G. Iowa.
Hall, S. P. Central States.
Hall, W. H. North Carolina.
Hallam, G. E. Pacific Northwest.
Hallock, E. C. New York.
Halpin, John. New York.
Hambleton, F. T. England (I. S. P.).
Hamilton, R. F. Pacific Northwest.
Hamlin, C. H. England (I. S. P.).

Hamm, William C. New York.
Hammond Board of San. Com. (Corporate) Central States.
Hammond, F. G. New York.
Hammond, George R. Pacific Northwest.
Hanapel, A. H. California.
Hanenberg, A. L. Canada.
Haney, Paul. Kansas.
Hanrath, William J. New England.
Hansell, Wm. A. Georgia.
Hansell, Wm. A., Jr. Georgia.
Hansen, Paul. Central States.
Hanson, George I. New England.
Hanson, H. G. North Dakota.
Hanson, John R. New York.
Hapgood, E. P. California.
Hardenbergh, W. A. New York.
Harding, J. C. New York.
Harding, Robert C. Pacific Northwest.
Hardman, T. T. Central States.
Hardy, C. Asa. New York.
Hardy, J. S. England (I. S. P.).
Harley, Frank E. New Jersey.
Harmeson, D. K. Central States.
Harmon, J. A. Central States.
Harmon, Judson A. California.
Harper, Charles E. Central States.
Harper, M. J. New England.
Harr, Neal. Kansas.
Harris, George C. Central States.
Harris, J. England (I. S. P.).
Harris, R. C. Canada.
Harris, T. R. Central States.
Harrison, Edward F. New York.
Harrison, John B. California.
Harrison, Martin C. Central States.
Harroun, F. E. Ohio.
Harstad, Howard T. Pacific Northwest.
Hart, Chas. G. New York.
Hart, W. B. Pennsylvania.
Hartman, B. J. Central States.
Hartman, Byron K. Central States.
Hartung, N. E. Central States.
Hartzell, E. F. Pennsylvania.
Harvey, Carl. New York.
Haseltine, T. R. Pennsylvania.
Hasfurther, Wm. A. Central States.
Haskins, Charles A. Missouri.
Hastie, James. New York.
Hatfield, W. D., Dr. Central States.
Hauck, Charles F. Ohio.
Hauer, Gerald. Central States.
Havens, William L. Ohio.
Hawken, Dalton. Michigan.
Hawley, Arthur A. New York.
Haworth, J. Victor. Pennsylvania.
Haworth, W. D. England (I. S. E.).
Hay, Julian A. Central States.
Hay, T. T. Central States.
Haydock, Chas. Pennsylvania.
Hayes, John A. New York.
Hayward, Homer J. Michigan.
Hazen, Richard. New York.
Heaslit, Walter. Rocky Mountain.
Hedgepeth, L. L. Pennsylvania (New York—Dual).
Hedges, Horace P. New York.
Heeg, H. H. Michigan (Alt.).
Heffelfinger, D. D. Ohio.
Heider, Robert W. Central States.
Heinrickson, J. J. Kansas.
Heiple, Loren R. Central States.
Heisig, H. M. Central States.
Heiss, Edward. Pacific Northwest.
Helland, H. R. F. Texas.
Henderlite, J. H. North Carolina.
Henderson, Chas. F. New York.
Hendon, H. H. New York.
Henel, Wm. F. New York.
Henn, Donald E. Central States.
Herberger, Arthur Henry. New York.
Herman, Frank. Oklahoma.
Herr, H. N. Pennsylvania.
Herrick, T. L. Central States.
Hersig, S. B. Central States.
Hesford, L. England (I. S. E.).
Hess, Daniel J., Jr. Pennsylvania.
Hess, Seth G. New York.
Heubi, Thomas. New York.
Heukelekian, H. New Jersey.
Hewitt, A. C. Pennsylvania.
Heyward, T. C. North Carolina.
Hibschman, Charles A. Pennsylvania.
Hickey, William. New York.
Hicks, Cyril. Michigan (Alt.).
Hicks, Geo. W. Central States.
Higgins, William J. New York.
Highberger, W. W. New York, New England.
Hill, Frank C. Rocky Mountain.
Hill, G. Everett. New York.
Hill, K. V. Central States.
Hill, Theo. C. Pennsylvania.
Hill, W. R. Pacific Northwest.
Hiller, Paul W. New England (New York—Dual).
Hilton, Elton M. California.
Hirschel, Leslie. New York.
Hitchner, A. H. California.
Hoag, Clarence C. New York.
Hoak, Richard D. Pennsylvania.
Hobson, N. C. Canada.
Hodek, James J. Maryland-Delaware.
Hodge, W. W. Pennsylvania.
Hodges, H. E. W. England (I. S. E.).

Hodgson, E. England (I. S. P.).
Hodgson, H. J. N. England (I. S. P.).
Hoeflich, G. C. Pennsylvania.
Hoey, John B. New York.
Hoff, Clarence W. Pennsylvania.
Hoffert, J. R. Pennsylvania.
Hogan, James W. T. New York.
Hogan, William J. New York.
Holden, E. G. Rocky Mountain.
Holderby, J. M. Central States.
Holderman, John S. Central States.
Holland, Frank H. New York.
Holloway, Frank M. New York.
Holmes, Glenn D. New York.
Holmes, Harry E. New England.
Holmes, Kenneth H. New England.
Holmgren, Richard F. New England.
Holmquist, Chas. A. New York.
Holroyd, A. England (I. S. P.).
Holst, J. S. South Dakota.
Holt, Clayton M. Central States.
Holtkamp, Leo. Iowa.
Holter, A. L. Pacific Northwest.
Holtje, Ralph H. New Jersey.
Holway, O. C. Central States.
Homelite Corporation. Associate.
Hommon, H. B. Federal, California.
Honens, R. W. Central States.
Honigman, Elkono G. New York.
Hoot, Ralph A. Central States.
Hoover, C. B. Ohio.
Hopkins, L. S. R. New York.
Hopkins, Omar C. Federal.
Hopper, Allen O. New York.
Horgan, John J. New York, New England.
Horn, A. John. New York.
Horne, Ralph W. New England.
Horton, F. C. California.
Hoskins, J. K. Federal.
Hoskinson, Carl M. California.
Hotchkiss, H. T., Jr. New York.
Houlihan, J. E. England (I. S. P.).
Houser, George C. New England.
Houston, W. J. Georgia.
Howard, C. M. Pacific Northwest.
Howard, N. J. Canada.
Howarth, J. P. England (I. S. P.).
Howe, Ben V. Rocky Mountain.
Howe, J. P. Canada.
Howe, W. A. Central States.
Howell, Eugene M. California.
Howland, W. E. Central States.
Howson, J. T. New York.
Howson, L. R. Central States.
Hoy, J. R. Florida.
Hoydar, Albert L. Pacific Northwest.
Hoyle, W. H. England (I. S. P.).
Hoyt, Clinton W. New York.
Hromada, Frank M. Central States.
Hubbell, George. Michigan.
Hubel, J. H. Canada.
Huber, Harold J. New York.
Hudson, LaVerne D. Central States.
Huebner, Ludwig. California.
Huffman, Lloyd C. Ohio.
Hughes, W. P. Pacific Northwest.
Hulak, S. M. New York.
Hults, William S., Jr. New York.
Humboldt, City of. Iowa.
Humphries, J. T. Georgia.
Hundt, Edward L. Michigan (Alt.).
Hunt, L. W. Central States.
Hunt, H. S. Michigan.
Hunter, A. England (I. S. P.).
Hupp, John E., Jr. Central States.
Hurd, Chas. H. Central States.
Hurd, Edwin C. Central States.
Hurley, J. England (I. S. P.).
Hurst, D. H. Georgia.
Hurst, Howard M. California.
Hurst, William C. New York.
Hurwitz, Emanuel. Central States.
Hussong, Ernest W. Central States.
Hutcheson, H. D. New York.
Hutchins, Will A. Central States.
Huth, Norman A. California.
Hutton, H. S. Pennsylvania.
Hyde, Charles Gilman. California.

Illinois Dept. of Public Health. (Corporate) Central States.
Indiana State Bd. of Health. (Corporate) Central States.
Ingalls, James. Pacific Northwest.
Ingols, Robert. New Jersey.
Ingrams, Wm. T. California.
Infilco. (Corporate) Central States.
Irwin, Forrest. Ohio.
Irwin, G. M. Pacific Northwest.
Iscol, George. New York.

Jablon, Fred M. New York.
Jack, D. Canada.
Jack, Grant R. Canada.
Jacklin, T. W. Canada.
Jackson, James A. Central States.
Jackson, J. Frederick. New England.
Jackson, R. B. Michigan.
Jackson, T. L. Michigan.
Jacobs, J. R. Georgia.
Jacobs, L. L. Georgia.
James, Norman S. Florida.
Jardine, M. E. Canada.
Jarlinski, Thaddeus T. New York.

Jeffrey Manufacturing Co. Associate.
Jeffrey, H. H. California.
Jeffries, Ernest W. New York.
Jenckes, J. Franklin, Jr. New England.
Jenks, Glen. Rocky Mountain.
Jenks, Harry N. California.
Jennings, A. England (I. S. P.).
Jennings, L. R. Michigan.
Jensen, Emil C. Pacific Northwest.
Jenson, Theodore B. Florida.
Jepson, C. England (I. S. P.).
Jerge, Ray. New York.
Jeup, Bernard H. Central States.
Jewell, H. W. California.
Johns-Manville Corp. Associate.
Johnson, Arthur N. Central States.
Johnson, Clement. New York (Alt.).
Johnson, Earle P. Pennsylvania.
Johnson, Eskil C. New England.
Johnson, Floyd E. Central States.
Johnson, Herbert O. New York.
Johnson, H. B. Pennsylvania.
Johnson, John W. New York.
Johnson, R. J. Central States.
Johnson, Verner C. California.
Jonas, Milton R. Central States.
Jones, A. N. Arizona.
Jones, C. B. O. England (I. S. P.).
Jones, Daniel. New York.
Jones, E. M. (New York—Dual) Pennsylvania.
Jones, Frank P. Michigan.
Jones, Frank Woodbury. Ohio.
Jones, S. Leary. Federal.
Jones, T. A. Georgia.
Jones, Wayland. California.
Jordan, Harry E. New York.
Jorgensen, Homer W. California.
Jost, Charles F. New York.
Joy, C. Fred, Jr. New England.

Kachmar, John F. Federal.
Kachorsky, M. S. New Jersey.
Kafka, John. Central States.
Kaler, P. E. Kansas.
Kammerling, Lane. Michigan.
Kaplan, Bernard. New Jersey.
Kappe, S. E. Pennsylvania (New York—Dual), New England.
Karalekas, Peter C. New England.
Karsa, Wm. J. New York.
Kass, Nathan I. New York.
Kassay, Albert E. New York.
Kearney, John J. Central States.
Keefer, C. E. Maryland.
Keefer, R. K. Pennsylvania.
Keeler, J. Harold. New York.
Kehr, Robert W. Federal.
Kehr, Wm. Q. Missouri.
Keirn, Kenneth A. California.
Keirns, Orval D. Ohio.
Kelleher, Joseph A. New York.
Keller, Dwight. Ohio.
Keller, Jacob. New York.
Keller, Lyndon M. New York.
Keller, Perry. Kansas.
Keller, S. K. Florida.
Kelley, R. E. Michigan.
Kellogg, Clarence E. New York.
Kellogg, James W. North Carolina.
Kelly, Clarence. New York.
Kelly, Earl M. California.
Kelsey, Walter. New York, New England.
Kemp, Harold A. New York.
Kempkey, A. California.
Kennedy, C. C. California.
Kennedy, D. R. California.
Kennedy, R. R. California.
Kenney, Norman D. Maryland-Delaware.
Kepner, Dana E. Rocky Mountain.
Kershaw, Arnold. England (I. S. P.).
Ketcham, Joseph M. New York.
Kibler, Harry J. New York.
Kidd, Carl W. New York.
Kieffer, Jos. D. New York.
Kiker, John E., Jr. New York.
Kilcawley, Edward J. New York.
Killam, E. T. New Jersey.
Kimball, Jack H. California.
Kin, Stephen R. New York.
King, Henry R. Central States.
King, Richard. Central States.
Kingsbury, Harold N. Central States.
Kingston, Paul S. Central States.
Kinney, J. B. Canada.
Kinsel, Harry L. Pennsylvania.
Kinsman, Frederick. California (Alt.).
Kirchoffer, W. G. Central States.
Kirn, Matt. Central States.
Kirsner, Charles. New York.
Kivari, A. M. California.
Kivell, Wayne A. New York.
Kjellberg, G. California (Alt.).
Klang, Marvin F. Michigan.
Klann, Martin C. Michigan.
Klegerman, M. H. New York.
Klein, J. A. Central States.
Klein, L. England (I. S. P.).
Kleiser, Paul J. Central States.
Klemme, Wm. W. New York.
Kleven, John. North Dakota.
Klinck, Frank. New York.
Kline, H. S. Ohio.
Klippel, Floyd. Iowa.

Klippel, R. M. Michigan.
Knapp, Glenn. Michigan (Alt.).
Knapton, William. California.
Knechtges, O. Central States.
Knoedler, H. A. California.
Knowlton, W. T. California.
Knox, W. H. Ohio.
Koch & Fowler. Texas.
Koch, Philip L. Central States.
Kochin, Milton S. Pennsylvania.
Kochtitzky, O. W. Federal.
Koebig, A. H., Jr. California.
Kolb, Fred W. California (Alt.).
Koon, Ray E. Pacific Northwest.
Koplowitz, Sol. New York.
Korfmacher, John A. Central States.
Kramer, Harry P. Central States.
Kratz, Herman. Maryland.
Kraus, L. S. Central States.
Krause, Ray. California.
Krell, A. J. New York.
Kremer, Robert W. Pennsylvania.
Kressly, Paul E. Califonria.
Kretschmar, Dr., G. G. Pacific Northwest.
Kreutter, Clarence. New York.
Kriegel, Paul O. New York.
Kronbach, Allan. Michigan.
Kroone, T. H. Ohio.
Krumm, Harry J. Pennsylvania.
Kuhner, Frank G. Central States.
Kulberg, Abraham J. New York.
Kulin, Harvey J. Central States.
Kunsch, Walter. New England.
Kunze, Albert T. Michigan.
Kupper, C. J. New Jersey.
Kurtz, Harold I. Pennsylvania.
Kussmaul, T. C. Ohio.
Kyte, W. O. California.

Laberteaux, Kenneth. Michigan.
Lacy, Ilbert O. New York.
Ladlow, John. Arizona.
La Due, Chas. J. Michigan (Alt.).
Lafreniere, Theo. J. Canada.
Lakeside Engineering Corp. (Corporate), Central States. Associate.
Lamb, Charles. Canada.
Lamb, Clarence F. New England.
Lamb, Miles. Central States.
Lamb, P., Esq. England (I. S. P.).
Lambert, Carl F. Florida.
Lamoureux, Vincent B. Federal.
Lamson, B. F. Canada.
Lang, Lloyd. Central States.
Lang, Wm. H. Pennsylvania.
Langdon, L. E. Central States.
Langdon, Paul E. Central States.
Langelier, W. F. California.
Langford, Leonard L. New York, New England, Pennsylvania.
Langton, Bernard. New Jersey.
Langwell, Louie. Central States.
Lannon, William. New England.
Lanphear, Roy S. New England.
Larkin, Donald G. New York.
Larkin, W. H. New York.
Larsen, Ernest A. New York.
Larsen, Stanley J. Central States.
Larson, C. C. Central States.
Larson, Keith D. Central States.
Larson, L. L. Central States.
La Rue, Luther. Ohio.
Laughlin, William G. New York.
Lauster, K. C. North Dakota.
Lautenschlager, Herbert. Ohio.
Lautz, Harold L. Central States.
LaValley, Edward C. New York.
LaVerty, Francis J. New York.
Lawlor, J. P. Iowa.
Lawrence, E. A. Ohio.
Lawrence, John. New York.
Lawson, W. S. Canada.
Lea, J. E. England (I. S. P.).
Lea, W. S. Canada.
Leach, Walter L. Ohio.
Leaver, R. E., Jr. Pacific Northwest.
Le Bosquet, M. Federal.
Le Chard, Joseph H. New Jersey.
LeClerc, Arthur B. North Carolina.
Ledford, Geo. L. New York.
Lee, Charles H. California.
Lee, David B. Florida.
Lee, Oliver. Central States.
Leemaster, J. F. Michigan.
Leggett, John T. California.
Leh, Willard. Pennsylvania.
Lehmann, Arthur F. New Jersey.
Lehr, Eugene L. New England.
Leigh, H. G. England (I. S. P.).
Leimbach, Harry. Pennsylvania.
Leist, Ervin F. Ohio.
Leland, Benn J. Central States.
Leland, Raymond I. Central States.
Lemcke, Ewald M. California.
Lendall, Prof. Harry N. New Jersey.
Lenert, Louva G. Georgia.
Lentfoehr, Charles E. Central States.
Leonard, Walter E. Ohio.
Leonhard, Harold M. Michigan.
Lesher, Carl. Ohio, Pennsylvania.
Lessig, D. H. Central States.
LeVan, J. H. Federal.
Lewis, John V. New York.
Lewis, R. K. Central States.

Ley, Charles H. Canada.
Lieber, Maxim. New York.
Liebman, Henry. New York.
Limestone Products Corp. of America. Associate.
Lind, A. Carlton. Central States.
Lindell, C. V. Missouri.
Linderman, Irving E. Central States.
Linders, Edward. Federal.
Lindgren, C. R., M.D. Pacific Northwest.
Lindsten, H. C. North Dakota.
Link-Belt Company. New York, Associate. (Corporate), Central States.
Lippelt, Hans B. New York.
Little, T. V. California.
Livingstone, Bard. California.
Lloyd, G. H. Canada.
Locke, Edw. A. New England.
Lockett, W. T. England (I. S. P.).
Lock Joint Pipe Co. Associate.
Lockwood, Bronson E. New England.
Loelkes, George L. Missouri.
Loeman, A. Hamilton. Central States.
Logan, Robert P. New Jersey.
Long, Frank V. California.
Long, George S. Pennsylvania.
Long, H. Maynard. Central States.
Long, James C. New Jersey.
Longlais, Zachie. Canada.
Loomis, Harry E. New York.
Los Angeles Public Library. California.
Lose, Charles, III. New York.
Losee, James R. New York.
Lovejoy, W. L. Pacific Northwest.
Lovell, Theodore R. Central States.
Lovett, F. W. Central States.
Lovett, M. England (I. S. P.).
Lowe, Prof. Thomas M. Georgia.
Lowe, Walter M. New York.
Lower, J. R. Ohio.
Lowther, Burton. California.
Lozier, William S. New York.
Lubratovich, M. D. Central States.
Luchtenberg, R. O. Ohio.
Ludlow Valve Mfg. Co. Associate.
Ludwig, Harvey F. California.
Ludwig, Russell G. California.
Luebbers, Ralph H. Missouri.
Lueck, Bernard F. Central States.
Luippold, G. T. California.
Lumb, C. England (I. S. P.).
Lusk, Charles W. New York.
Lustig, Joseph. Central States.
Luther, L. L. New York.
Luther, Robert W. North Carolina.
Lutz, Howland C. Pennsylvania.
Lux, Kathleen F. Central States.
Lynch, Daniel E., Jr. New York.
Lynch, James T. New York.
Lynchburg Foundry Company. Associate.
Lyons, William. New York.

McAdoo & Allen Welting Company. (Corporate) Pennsylvania.
McAnlis, Chauncey R. Central States.
McArthur, Franklin. Canada.
McBride, J. L. California.
McCall, R. G. Central States.
McCallum, G. E. Federal.
McCannel, D. A. R. Canada.
McCarthy, Joseph A. New England.
McCarthy, Justin J. New York.
McCarthy, William F. New York.
McCleary, E. L. Pacific Northwest.
McClenahan, W. J. Central States.
McClintock, H. C. Rocky Mountain.
McClure, Ernest. Central States.
McDill, Bruce M. Ohio.
McDonald, John. New England.
McDonald, N. G. Canada.
McDonald, Roland G. New York.
McDonnell, George H. New York.
McDuell, John W. California.
McFarlane, Walter D. Michigan.
McFaul, W. L. Canada.
McGrath, C. P. Michigan.
McGuire, C. D. Ohio.
McGurk, Sam R., Jr. Central States.
McIlvaine, Wm. D., Jr. Central States.
McIntyre, F. J. Ohio.
McIntyre, John C. Central States.
McKay, R. Donald. Canada.
McKee, Frank J. Central States.
McKee, Jack E. New England.
McKeeman, Edwin C. New York.
McKeen, William H. California.
McKenna, Harold R. Michigan.
McKinlay, Daniel. California.
McLaughlin, John. New Jersey.
McLean, Clement. New York.
McLean, R. F. Pacific Northwest.
McMahon, Walter A. New England.
McManamna, T. L. Canada.
McMenamin, C. B. New Jersey.
McMillan, Donald C. California.
McMorrow, Bernard J. California.
McNamee, Paul D. Federal.
McNeal, Leonard. Ohio.
McNicholas, J. England (I. S. P.).
McNiece, L. G. Canada.
McRae, John C. Michigan.
McWilliams, D. B. Canada.
Mabbs, John W. Central States.
Macabee, Lloyd C. California.

Macauley, J. W. New York.
MacCallum, C. New York.
MacCallum, Percy C. New York.
MacCrea, J. M. New York.
MacDonald, J. C. Central States.
MacDowell, R. F. Ohio.
Mack, Frank. New York.
MacKenzie, Vernon G. Federal.
Mackin, John C. Central States.
MacLachlan, Angus. Ohio.
MacLaren, J. F. Canada.
MacLean, J. D. Canada.
Madison, James W. Central States.
Maga, John A. California.
Magee, Geo. W. New York.
Maguire, Chas. C. New England.
Mahlie, W. S. Texas.
Maier, F. J. Federal.
Makepeace, W. H. England (I. S. P.).
Malcolm, Wm. L. New York.
Mallalieu, W. C. New Jersey.
Mallman, W. L. Michigan.
Malloy, Howard. Michigan.
Malone, J. R. North Carolina.
Maloney, W. L. Pacific Northwest.
Mallory, Edward B. New York, Pennsylvania, Central States.
Mann, Alfred H. New York.
Mann, Uhl T. New York.
Mannheim, Robert. New England.
Mansfield, M. G. Pennsylvania.
Manteufel, Lawrence A. Central States.
Marchon, Seigmund S. New York.
Mariner, W. S. New England.
Marsh, H. M. Canada.
Marshall, E. A. New York.
Marshall, J. C. Michigan (Alt.).
Marshall, Leslie S. New York.
Marshall, W. B. New York.
Martens, L. P. Central States.
Martin, A. E. New York.
Martin, Alexander G. New York.
Martin, Edw. J., Jr. New York.
Martin, George C. Central States.
Martin, Phil J. Arizona.
Martin, Sylvan C. Central States.
Martzell, Paul C. New England.
Marx, Frank. New York.
Marx, Geo. W. Arizona.
Maryland State Dept. of Health. Maryland-Delaware.
Mason, Clarence A. Central States.
Masselli, Joseph William. New England.
Mather, Edward K. South Dakota.
Mathers, George. New York.
Mathews, E. R. South Dakota.
Mathews, Frank E. Pacific Northwest.
Mathews, L. R. Central States.
Mathews, W. W. Central States.
Mathieson Alkali Works, Inc. Associate.
Mathis, Alice. Arizona.
Matter, L. D. Pennsylvania.
Mattheis, Clarence. Central States.
May, D. C. Michigan.
May, Harold L. California.
Mebus, George B. Pennsylvania.
Mechler, Louis W. California.
Medberry, H. Christopher. California.
Meeker, Herbert J. New York.
Meiers, Walter W. New York.
Mendelsohn, I. W. New York.
Menefee, James H. Texas.
Menzies, D. B. Canada.
Merkel, Paul P. Pennsylvania.
Meron, L. A. New York.
Merrill, Walter E. New England.
Merritt, Will D. North Carolina.
Merryfield, Fred. Pacific Northwest.
Merz, H. Spencer. Central States.
Mesner, Elmer C. New York.
Meyer, Louis P. H. California.
Michael, A. M. Florida.
Michaels, John. New York.
Mick, K. L. Central States.
Mickle, Chas. T. Central States.
Middleton, Francis M. Federal.
Miick, Fred E. California.
Miles, Henry J. Florida.
Milinowski, Arthur S. Central States.
Miller, A. P. Federal.
Miller, A. S. England (I. S. P.).
Miller, Alden W. Arizona.
Miller, Fred M. New York.
Miller, John B. Florida.
Miller, J. John. Pennsylvania.
Miller, L. A. Central States.
Miller, Lester. Central States.
Miller, Robert G. Iowa.
Miller, Roy. Pennsylvania.
Miller, W. C. Canada.
Miller, Wallace T. New York.
Milligan, Francis B. Pennsylvania.
Milliken, Harold E. New York.
Milling, Martin A. Central States.
Mills, S. W. Canada.
Minneapolis-St. Paul San. Dist. (Corporate) Central States.
Minner, Donald T., California.
Mitchell, Burton F. New England.
Mitchell, Louis. New York.
Mitchell, Robert D. South Dakota.
Modak, B. L. England (I. S. P.).
Modak, N. V. England (I. S. P.).
Mogelnicki, Stanley. Michigan.

Moggio, Wm. A. North Carolina.
Mohlman, F. W., Dr. Central States.
Molitor, Edward P. New Jersey.
Molitor, Paul, Major. California.
Monk, H. W. England (I. S. P.).
Monroe, S. G. Ohio.
Monsanto Chemical Company. Associate.
Monsell, Harry M. New York.
Montanari, Francis W. New York.
Montgomery, J. Robert. Michigan.
Montreal, City of. Canada.
Moor, Alex. New York (Alt.).
Moor, W. C. Texas.
Moore, Charles A. Pennsylvania.
Moore, Edward W. New England.
Moore, F. Owen. England (I. S. E.).
Moore, Geo. S. North Carolina.
Moore, George W. New York.
Moore, Herbert. Central States.
Moore, R. B. Central States.
Moore, R. L. England (I. S. P.).
Moore, W. A. Federal.
Morehouse, W. W. Ohio
Morey, Burrows. New York.
Morgan, Edward F., Jr. New England.
Morgan, Philip F. Central States.
Morgenroth, Fritz. New England.
Morin, A. Canada.
Morkert, Kenneth. Central States.
Morrill, Arthur. Michigan.
Morris, Arval. California (Alt.).
Morris, Lee. South Dakota.
Morris, Paul J. Pennsylvania.
Morrissette, Romeo. Canada.
Morrow, Ben. Pacific Northwest.
Moses, H. E. Pennsylvania.
Moss, F. J. Federal.
Mott, C. A. Canada.
Mott, Robert D. Iowa.
Mountfort, L. F. England (I. S. P.).
Mount Penn, Borough of. Pennsylvania.
Mowbray, George A. New York.
Mower, Stanley E. New York.
Mowrey, J. Hase. Pennsylvania.
Mowry, Robert B. Pennsylvania.
Mudgett, C. T. Michigan.
Muegge, O. J. Central States.
Mueller Company. Associate.
Muldoon, Joseph A. New England.
Mullinex, Chas. D. Iowa.
Munding, Miss Germaine G. New York.
Munford, Mrs. G. England (I. S. P.).
Munroe, W. C. Maryland.
Munson, Laura A., Mrs. California.
Murdock, William. Pennsylvania.
Murphy, Lindon J. Iowa.
Murphy, Reginald A. New York.
Murray, A. E. Scott, Esq. England (I. S. E.).
Murschel, Jacob. South Dakota.
Musgrove, Robert. Michigan.
Mutzberg, F. A. Georgia.
Myers, Harry L. Central States.

Nance, E. L. North Carolina.
Nasi, Kaarlo W. California.
National Water Main Cleaning Co. Associate.
Nauer, Louis A., Jr. Central States.
Naylor, William. New England.
Neiman, W. T. Central States.
Nelle, Richard S. Central States.
Nelson, Ben O. Pacific Northwest.
Nelson, Frederick G. Ohio.
Nemmers, W. P. Iowa.
Nesheim, Arnold. Federal.
Netto, J. P. De Lemos. New York.
Neves, Dr. Lourenco Baeta. New York.
Nevitt, I. H. New York.
Newell, Town of. Iowa.
Newland, Stewart H. Texas.
Newlands, James A. New England.
Newman, Alfred C. Florida.
Newsom, Reeves. New York.
Newton, City of. Iowa.
Newton, G. D. Georgia.
Nicholas, Forrest A. Central States.
Nichols, Arthur E. New York.
Nichols Engineering & Research Corp. Associate.
Nichols, M. Starr. Central States.
Nicholson, C. P. New York.
Nickel, Jack B. Central States.
Nicklin, H. S. Canada.
Nicoli, Frank A. New England.
Nielsen, A. F. New York.
Niemi, Arthur G. Central States.
Niles, A. H. Ohio.
Niles, Thomas M. Central States.
Nixon, J. England (I. S. P.).
Nordell, Carl H. Central States.
Norfleet, Clark T. California (Alt.).
Norgaard, John. Michigan.
Norris, Francis I. Federal.
Norris, Harold E. Central States.
North English, Town of. Iowa.
Nugent, Franklin J. Pennsylvania.
Nugent, Harold F. New York.
Nugent, Lee M. California.
Nusbaum, I. Michigan.
Nussbaumer, Newell L. New York.
Nussberger, Fred. New York.

Obma, Chester A. Central States.
O'Brien, Earl F. New York.
Ocean City Sewer Service Co. New Jersey.

Ockershausen, Richard W. New York.
O'Connell, Wm. J. California.
O'Connor, William F., Jr. New York.
O'Dell, W. H. New York.
O'Donnell, R. Pennsylvania.
Oeming, L. F. Michigan.
O'Flaherty, Dr. Fred. Ohio.
Ogden, H. N., Prof. New York.
Ogle, Harry B. California (Alt.).
O'Hara, Franklin. New York.
Ohr, Milo F. Michigan.
Oke, Ernest E. W. Canada.
Okun, Abraham H. New York.
Okun, Daniel A. Central States.
Okun, W. H. New York.
Old, H. N. Federal.
O'Leary, William A. New York.
Olewiler, Grant M. Pennsylvania.
Oliver, J. C. Texas.
Oliver, Willis. Kansas.
Olsen, W. C. North Carolina.
Olson, Frank W. Central States.
Olson, Herbert A. Michigan.
O'Mara, Richard. Central States.
O'Neill, Ralph W. California.
Ongerth, H. J. California.
Orchard, W. J. New York, New Jersey.
Orton, J. W. Michigan.
Osage, City of. Iowa.
Osborn, L. C. Rocky Mountain.
O'Toole, Matthew. New York.
Otterson, H. A. Pennsylvania.
Owings, Noble L. Maryland-Delaware.

Pacific Flush Tank Co. (Corporate) Central States, Associate.
Paessler, Alfred H. Texas.
Page, Ronald C. California.
Painter, Carl E. California.
Palange, Ralph C. Federal.
Pallo, Peter E. New York.
Palmer, Benjamin M. New England.
Palmer, C. L. Michigan.
Palmer, Harold K. California.
Palmer, I. Charles. Pennsylvania.
Palmer, John R. Central States.
Palocsay, Frank S. Ohio.
Parks, G. A. California.
Parsons, R. H. Canada.
Patriarche, John M. Michigan.
Patterson, Roy K. New York.
Paul, Lewis C. New York.
Paul, Richard B. Pennsylvania.
Pawlak, John S. New York.
Payrow, Harry G. Pennsylvania.
Pearl, Emanuel H. Texas.
Pearse, Langdon. Honorary, Central States.
Pearson, E. J. North Dakota.
Pease, Maxfield. Ohio.
Peck, Lawrence J. New York.
Peirce, W. A. Central States.
Peirson, Henry C. California (Alt.).
Pennsylvania Salt Mfg. Co. Associate.
Perkins, J. L. North Carolina.
Perrine, J. Franklin. New York.
Perroni, Joseph. New York.
Perry, Earl R. New England.
Peterson, A. H. California (Alt.).
Peterson, Earl L. New York.
Peterson, Ivan C. Central States.
Peterson, Myhren C. Central States.
Peterson, Ralph W. Central States.
Petrie, William P. New England.
Pettit, Charles. Ohio.
Peyton, James J. New York.
Pfeiler, L. F. Central States.
Phelps, B. D. California.
Phelps, E. B., Prof. New York.
Phelps, Geo. Canada.
Phelps, Tracy I. California.
Phillips, H. N. New York.
Phillips, Roy L. Pennsylvania.
Phillips, R. S. North Carolina.
Piatt, Wm. M. North Carolina.
Pickett, Arthur G. California.
Pieczonka, Thaddeus. New York.
Pierce, C. L. California.
Pierce, George O. Central States.
Pierce, W. E. Michigan (Alt.).
Pierron, L. L. Ohio.
Pierron, Wm. Sr. Pacific Northwest.
Pincus, Sol. New York.
Pinkney, Glenn E. New York.
Pinney, F. W. North Dakota.
Pintar, Geo. Pennsylvania.
Pitkin, Ward H. New York.
Pittsburgh-Des Moines Co. Associate.
Pittsburgh Equitable Meter Co. Associate.
Pizie, Stuart G. Florida.
Plamondon, Sarto. Canada.
Pledger, A. England (I. S. P.).
Plummer, Raymond B. Central States.
Pohl, C. A., Dr. New York.
Pollex, Elmer. Ohio.
Pollock, John M. New York.
Pomeroy, Clarence. Michigan.
Pomeroy, Richard. California.
Pool, Charles L. New England.
Poole, B. A. Central States.
Poole, S. B. England (I. S. P.).
Pope, Lester. New Jersey.
Popp, W. L. California.
Porges, Ralph. New Jersey.
Porteus, W. K. England (I. S. E.).

Porter, H. California.
Porter, William. New York.
Post, Fred W. California (Alt.).
Poston, R. F. South Dakota.
Potter, Robert A. California.
Potts, Clyde. New York.
Potts, Harry G. Michigan.
Powell, A. R., Dr. New York.
Powell, S. T. Maryland-Delaware.
Powers, E. C. Ohio.
Powers, Leo. New York.
Pratt, Gilbert H. New England.
Pratt, Jack W. California.
Prendergast, John W. Arizona.
Price, Charles R. South Dakota.
Pringle, H. L. Canada.
Proportioneers Incorporated. Associate.
Proudman, Chester F. New England.
Provost, Andrew J., Jr. New York.
Public Works Magazine. Associate.
Puckhaber, Fred H. Texas.
Puffer, Stephen P. New England.
Prudie, David J. New York.
Purser, John R., Jr. North Carolina.

Quaely, Martin F. New York.
Quigley Company, Inc. Associate.
Quinn, Joseph L., Jr. Central States.

Racek, L., Jr. Central States.
Radcliffe, Jack C. New Jersey.
Raisch, William. New York, New England.
Ralston, Wilmer R. Pennsylvania.
Ramseier, Roy E. California.
Rankin, R. S. Central States.
Rantsma, W. F. California.
Rath, Henry M. New York.
Rauscher, Forrest L. Ohio.
Rawlins, George S. North Carolina.
Rawn, A. M. California.
Raymond, N. I. Michigan.
Redding, Harry P. North Carolina.
Redfern, W. B. Canada.
Reed, Leon H. New England.
Reed, Paul W. Central States.
Reed, Ralph. South Dakota.
Reedy, Timothy D. Michigan.
Rees, N. B. Central States.
Reese, Marshall. Pennsylvania.
Reeves, C. F. California.
Reeves, R. B. Kansas.
Regelsen, Alfred E. New York.
Regester, Robert T. Maryland-Delaware.
Rehler, Joseph E. New York.
Reidell, Alfred G. California.
Reilly, John J. Pennsylvania.
Rein, L. E. Central States.
Reiners, A. H. Iowa.
Reinke, Edward A. California.
Reisert, Michael J. New York.
Remsen, John. New York.
Reuning, Howard T. Pennsylvania.
Requardt, G. J. New York.
Reybold, E. C. Rocky Mountain.
Reybold, D. C. Central States.
Reynolds, Leon B., Prof. California.
Reynoldson, T. B. England (I. S. P.).
Rhoads, Edward J. Pennsylvania.
Ribal, Raymond Robt. California.
Ribner, Morris. New York.
Rice, Archie H. Pacific Northwest.
Rice, John M. Pennsylvania.
Rice, Lawrence G. New York.
Rice, Lawrence H. New York.
Richards, P. W. Central States.
Richardson, Charles S. New England.
Richey, C. E. Iowa.
Richgruber, Martin. Central States.
Richheimer, Chas. E. Florida.
Richmen, W. F. Central States.
Richter, Paul O. Central States.
Rickard, Grover E. New York.
Ricker, W. H., Jr. Pennsylvania.
Riddick, Thomas M. New York.
Ridenour, G. M. New Jersey.
Riedel, John C. New York.
Riedesel, Henry A. Central States.
Riedesel, P. W. Central States.
Riehl, W. H., Esq. Canada.
Riffe, Norman T. California (Alt.).
Riis-Cartensen, Erik. New York.
Ritter, Bruce. Michigan (Alt.).
Roab, F. H. Central States.
Roahrig, Henry L. Central States.
Robb, Charles G. New England.
Roberton, L. T. Canada.
Roberts, A. L. Arizona.
Roberts, C. R., Dr. New York.
Roberts, F. C., Jr. Arizona.
Roberts, Jack. New York.
Roberts, W. C. California.
Robins, Maurice L. Central States.
Robinson, B. Canada.
Robinson, G. G. Canada.
Robinson, George L. New York.
Robinson, I. F. Canada.
Robinson, J. C. South Dakota.
Rocco, John. New York.
Rock, Harold F. New York.
Roe, Frank C. Central States, New York.
Roetman, Edmond T. Pennsylvania.
Rogers, Allan H. New York.
Rogers, Harvey G. Central States.
Rogers, John A. New England.

Rogers, Milford E. Kansas.
Rogers, M. W. Canada.
Rogers, W. F. Central States.
Rohlich, Gerard A. Central States.
Romaine, Burr. Central States.
Rosemeyer, Alfred. Central States.
Rosengarten, W. E. Pennsylvania.
Ross, Herman M. Central States.
Ross, W. E. Central States.
Roth, R. F. Ohio.
Rowen, R. W. Central States.
Rowntree, Bernard. California.
Royer Foundry & Machine Co. Associate.
Ruble, E. H. Central States.
Ruchhoft, C. C. Central States, Federal.
Ruck, Franklin. Ohio.
Rudgal, H. T. Central States.
Rudolf, R. L. California.
Rudolfs, Dr., Willem. New Jersey.
Rue, Robert. Ohio.
Ruge, J. Herman. Florida.
Ruggles, M. H. Florida.
Rumble, George B. Canada.
Rumsey, James R. Michigan.
Rupp, Daniel H. Ohio.
Russell, Don B. Iowa.
Russell, George. Missouri.
Russell, J. P. Canada.
Ryan, Joseph P. Central States.
Ryan, J. Samuel. New York.
Ryan, William A. New York.
Ryckman, Seymour J. New England.

Saetre, Leif. New York.
Sage, Howard D. New York.
Sager, John C. Central States.
Sakellarian, Evans N. Central States.
Salle, Anthony. New York.
Salvato, Joseph. New York.
Sammis, L. A. New York.
Sampson, J. A. Iowa.
Samson, Channel. New York.
Sanborn, J. F. New York.
Sanchis, Jos. M. California.
Sanders, M.D. Central States.
Sanderson, W. W. New England (New York —Dual).
Sargent, Edward C. Ohio.
Sauer, Victor W. California.
Saunders, E. F. Central States.
Savage, Edward. New York.
Savage, William T., Jr. Central States.
Saville, Thorndike. New York.
Sawyer, Clair N. New York.
Sawyer, Robert W., Jr. New England.
Scales, J. J. Michigan.
Schade, Willard F. Ohio.
Schaefer, Edward J. New York.
Schaetzle, T. C. Ohio.
Schaut, George G. Pennsylvania.
Scheak, H. M. Canada.
Scheffer, Louis K. Pennsylvania.
Scheidt, Burton A. Central States.
Schenk, E. E. Iowa.
Schier, Lester C. Central States.
Schirk, J. M. Rocky Mountain.
Schlenz, H. E. Central States.
Schliekelman, R. J. Iowa.
Schlueter, William H. Central States.
Schmidt, J. M. Rocky Mountain.
Schneider, P. California.
Schneller, M. P. Central States.
Schoeninger, C. J. Michigan.
Schoepfle, O. F. Ohio.
Schouten, Ernest W.
Schrack, Bert. Iowa.
Schreiner, W. R. New York.
Schriner, P. J. Central States.
Schroeder, A. W. Central States.
Schroeder, W. L. South Dakota.
Schroepfer, George J. Central States.
Schuck, H. W. California.
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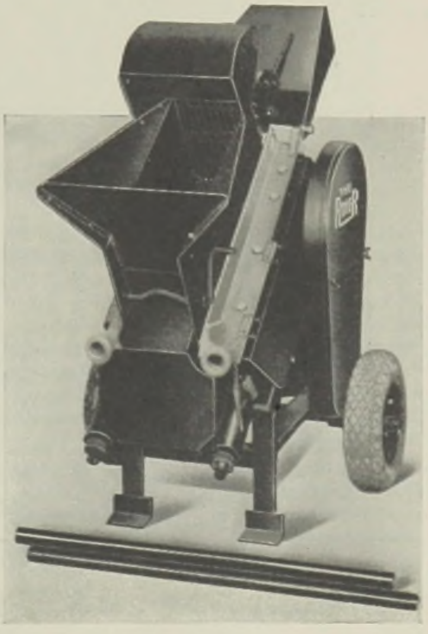

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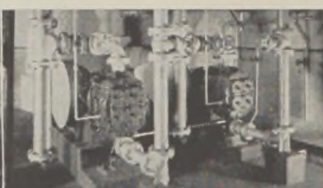

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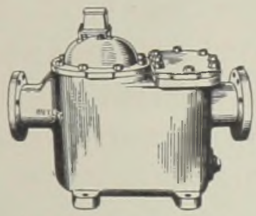

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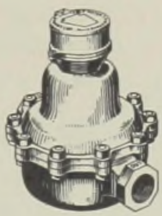

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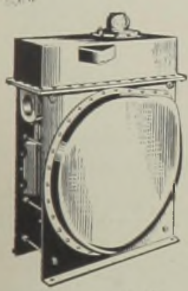

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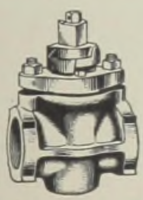

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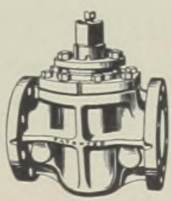

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