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SEWAGE WORKS JOURNAL

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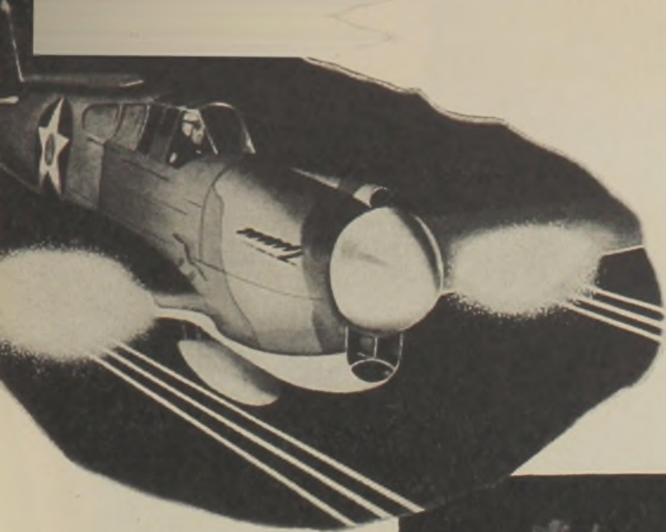

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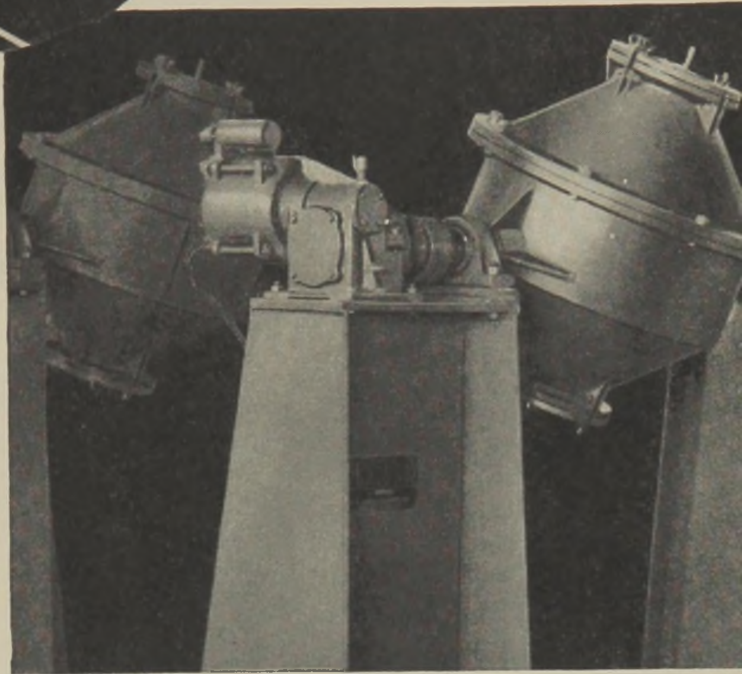

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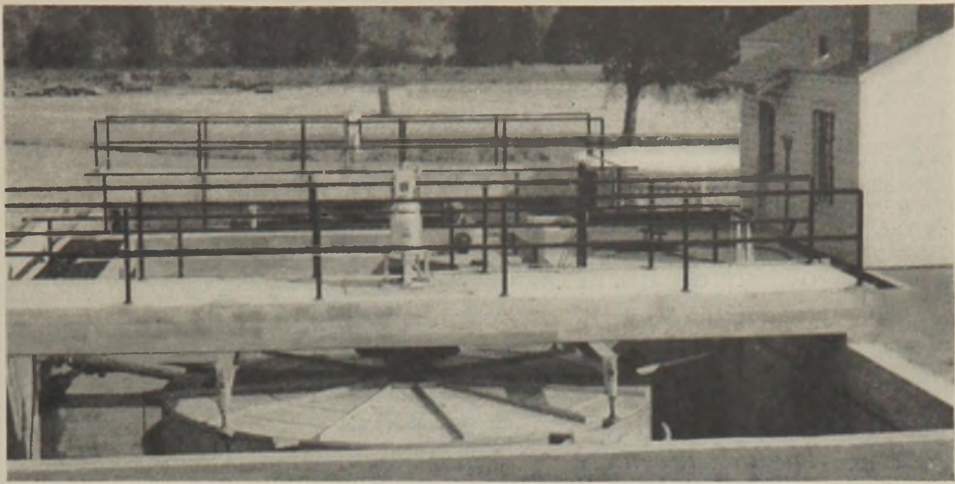

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Plant Operation

THE INFLUENCE OF THIS WAR UPON SEWERAGE PROBLEMS *

By A. M. Rawn

Chief Engineer and General Manager, County Sanitation Districts of Los Angeles County

Step by step the working population of this nation, excepting only those absolutely essential in the conduct of limited civilian activities, is being drawn into the country's armed forces, or to occupations which have the objective of placing a well equipped war machine in contact with the common enemy. Demands of the war machine in equipment and materials leave the civilian activities without a great many items deemed essential a short time ago. Sewerage has not been simplified with the advent of war; if anything, sewage treatment grows more perplexing, and authorities now find it necessary to adjust to the position of having to do more and more with less and less.

So much has transpired in leading up to our present national position, and seemingly so suddenly, that it is difficult to realize that restriction of civilian activities commenced nearly three years ago, and that the transition from comparative freedom of action to present day restraints was in fact somewhat gradual, gaining momentum as it proceeded and now accelerating at a rate which may leave us hanging on the ropes at times in the future.

In order to define the trend of activities which has led to present conditions in our field, it seems advisable to turn back the pages of recent history to the early part of 1940 and to pursue briefly events from then until now, determining, if possible, a curve of happenings which extrapolated will permit some crystal gazing, some predictions for the future which may have a fair opportunity of being correct. In this pursuit a number of general factors will develop, each of which has had its influence upon the activity under discussion. Materials, equipment, man-power, migration of population, sewage characteristics, and the lure of high wages and short hours elsewhere—all have had telling effect upon sewerage administration, which although in its relation to public health, is so essential a service as to receive special consideration from national agencies, has even so undergone some hard body blows—and will probably absorb many more before the advent of peace.

Along in the spring of 1940, the United States commenced an active expansion of its armed forces and embarked upon what was then considered a fairly impressive defense program. Three billion dollars were appropriated by Congress in May (1940) for that purpose, and

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

immediately thereafter Federal Works Relief activities were curtailed to the extent that appropriations therefor carried a condition that Federal aid would not be extended to non-defense construction estimated to cost over $100,000 per building project. In August, 1940, the Army awarded contracts for $50,000,000 worth of ordnance manufacturing plants and a storage depot, and at the same time commenced cantonment construction for an Army of 400,000 men. So far, the effect upon civilian pursuits not connected with defense was a slight tightening in the labor and material market—a warning of certain material shortages and the diversion of some Federal aid activities from public to defense works. Some Reserve Officers were called into active duty.

In September, Congress completed action on a five billion dollar defense appropriation and shortly thereafter shipyard construction for a two-ocean Navy commenced. Population comprising mostly workers began to concentrate in unusual places, and Federal agencies charged with the work of constructing cantonments, air fields, shipyards, defense plants, and the like encountered difficulties in environmental sanitation, particularly as it related to the disposal of the sewage of the working forces engaged in their construction. The very criteria which located Army plants and facilities tended to place them where sewerage systems were designed for limited local needs or totally non-existent, and the Army—more frequently than other branches—was confronted with the necessity of going into the sewerage business on a fairly extensive scale. Registration for the first conscription was October 16, 1940.

During October, two of the country's sanitary engineering firms were retained by the War Dept. for study and recommend appropriate sanitary facilities for twenty-five Army cantonments—some new and a number already built. Enlargement of garrisons at existing camps rendered it necessary that the sewerage facilities there be greatly expanded, or materially modified, if current ideas of sanitation were to be maintained. The report which these consulting engineering firms prepared is the basis for present day Army camp sanitation. Into its compilation went factors to be used in design which were, and are, deemed adequate to meet most situations arising over the country.

Throughout the following year (1941), Federal Building for defense increased rapidly both in tempo and volume. Salaries and wages paid by those engaged in the program were so attractive as to lure many skilled workmen away from non-defense activities, and the shortage of trained man-power in civilian pursuits became increasingly apparent. During 1941 there was no freezing of labor in its position and it was unnecessary for a man to show cause for leaving one employer and entering the services of another. In fact, the labor problem resolved itself into a matter of who wanted the individual most and was willing to offer the greatest inducements to get him.

In the series of events which transpired in 1941, sewerage forces, in common with services in other lower levels of government, were increasingly disturbed by loss of experienced help, professional and otherwise. Authorities were being confronted with the necessity of increasing wages and salaries or losing their personnel. The Priorities Division of OPM had placed restrictions upon enough materials to render new construction difficult but not impossible. Smaller communities, confronted with the influx of large groups of workmen, were greatly troubled by change in quantity and, to a lesser extent, in character of sewage flows.

In December, 1941, after the declaration of war, a ten billion dollar third supplemental Federal appropriation was authorized, including three and a half billion dollars for construction. Non-defense work, which had been scrutinized with some care before December 7, was now more carefully examined by WPB in the light of its use of critical materials and man-power, and the country as a whole was called upon to avoid the use of many scarce materials, even though a pre-war priority permitted their purchase. Thoughtful men the country over took cognizance of the situation and rendered what aid they could; others were more selfish. Substitutes began to be mentioned. Zinc, copper, rubber and aluminum were rapidly retired from other than defense construction. Steel began to disappear. In January (1942) Congress appropriated in excess of twenty-eight billion dollars for defense activities, and authorized an Army of 3,600,000.

With the buying power of thirty-eight billion dollars, urged on by the necessity for speeding up training of a greatly expanded Army, and further actuated by the idea that the United States must rapidly become the "Arsenal of Democracy," defense industries and the armed forces began inroads upon the man-power of the nation at an unprecented rate. Sewerage administrators speedily reconciled themselves to losing the younger, physically fit members of their organizations, and also came to the realization that salaries and wages paid by their levels of government were not much competition to those which organized labor was demanding and receiving from defense works. The flow of material into non-defense activities became more sluggish and OPA discussed the advisability of securing inventories from all departments of government, and from business, to force hoarded materials into the market—prevent non-defense construction without Federal authorization—and compel industries and public services to use up their stocks before purchasing more.

Prior to this—in August, 1941—an Act of Congress had provided a fund of $150,000,000 (since greatly increased) which was to be used at the President's discretion to expand and extend municipal facilities in areas where defense activities had rendered such facilities inadequate and where it was not deemed possible for the local citizenry to supply the necessary funds for such construction. This was known as the Community Facilities Fund. From August, 1941, until along in February of 1942, the objectives for which much of the fund was appropriate brought some despair to public works officials who realized, or felt reasonably sure, that schools, playgrounds, recreation halls, libraries, etc., should follow in the wake of, and not precede, such essential public services as water supply, sewerage, power development, police protection, roads, etc. In February of 1942, a reorganized FWA corrected the situation, and the Community Facilities money began to flow into channels of construction to provide the more essential services. The effect of this was to relieve to a limited extent the strain being placed upon overtaxed sewerage systems; or to provide such works where they were sorely needed, and did not exist.

The following March, the War Production Board issued its first war material scarcity list, subdivided into three general groups: First, those most vitally needed for war purposes and not generally available for civilian needs; second, those basically needed in war industry but not as scarce as those first noted; and third, those materials which were available in limited amounts for other than war purposes. The following month, WPB issued Order L–41 forbidding initiation of major non-defense projects without specific approval. This effectively stopped construction of any contemplated new sewerage works. Cases in point were Tulsa's million dollar sewerage plan; Baltimore's three and a half-million dollar public works undertaking—in part sewerage; and the abandonment of hopes for prompt construction of Los Angeles' many million dollar sewerage scheme. These and many more must now await war developments.

Since April (1942) there have followed in rapid sequence, from the increasingly powerful WPB, instructions which have limited the use of steel and other critical materials to defense construction and production. Even in current Army cantonment construction, sewerage works are designed with a minimum of critical materials. The shortage of reinforcing bars, or their diversion to strictly defense construction, is apparent in WPB's order to designers to calculate reinforcing steel quantity upon the basis of a value of 24,000 pounds per square inch tensile strength instead of the safer values used previously. This might be deemed reinforcing a structure with a stronger theory, but seems sound reasoning nevertheless. Subsequent to April, commodity prices have been fairly well frozen as of last March; all building has been stopped on structures such as amusement facilities and other non-essential projects already under construction; and orders have been issued to the effect that "all construction shall be of the cheapest temporary character"—sufficient only for usefulness during the emergency. Federal Aid Defense Housing Projects—at least in the West—appear to be limited to the building of the most inexpensive type of single family dwellings for small families.

In June, the war man-power commission propounded a plan to freeze war workers in their jobs and to make the United States Employment Service a clearing house for all workmen in the country, with the end in view of keeping men needed in critical positions at their stations and not allowing the lure of high wages to continue the disorganization of forces engaged in essential services. More recently there has appeared a plan to stop volunteer enlistments in the armed forces and to conscript the entire remaining man-power of the nation, delegate it to its duties, and allow little, if any, freedom of individual action.

Last May there was a feeling that defense construction was on the wane; that production in already constructed plants was so much greater than originally anticipated as to render further plant building useless because of insufficient workmen and materials. Concurrently it was stated that there were still a number of large war industries to build—among them those manufacturing steel, aluminum, magnesium, synthetic rubber and high octane gasoline. No let-up in material restrictions was predicted because critical materials were still critical; and 1943 levels of manufacturing in defense industries would consume all that could be provided. Since May, however, it has been noted that defense construction appears to be going on at a great rate and that the labor shortage, which cessation of building might have helped alleviate, is not helped much. There is again a rumor current that defense plant construction is over the hump at least within our national boundaries.

Thus, as of the late summer and early fall months of 1942, an examination of the picture, with respect to sewerage, discloses that those charged with the responsibility of this public health operation are confronted with, among others, the following circumstances:

Materials for construction are so limited that even the designers of sewerage works in new Army cantonments are instructed to eliminate all critical materials; to substitute mass concrete and timber for reinforced concrete and steel; and to do away with devices which encroach upon the metallic supplies so greatly needed in the war industries.

It is substantially impossible for extensions to sewerage works to be constructed, or for new treatment plants to be installed, except where, beyond the shadow of a doubt, there is a definite public health menace.

Equipment, including pumps, engines, motors, pipes (ferrous and clay) and valves, electrical wiring and appliances, and other metallic equipment, including manhole covers, rings and steps, may be obtained only for repairs and not for extensions, without specific authority upon adequate and unquestioned showing of necessity.

Man-power is critical. Were all of the members of the component associations of the Federation to have been assembled in one group in early 1940 and divided at random into groups of eight men each, and were they then to resemble as of the present date, it is likely that at least one member of each group of eight would be missing—gone to defense works or to the armed forces. The shortage of man-power—professional men and skilled workers trained in the science of sewage collection, treatment and disposal—is perhaps the most serious of all problems confronted by sewerage authorities. It is difficult to train men for this type of work, and it is the usual experience that only certain ones selected with some care adapt themselves to employment of this character. Untrained men are more of a liability than an asset because of certain personal dangers involved on the work. National authorities have been quick to recognize the importance of sewerage in the scheme of public health during this national emergency, but that recognition has not limited nor defined the activities of local draft boards by any means, and a man's employment in a responsible position in the scheme of sewage disposal has not, so far, appeared to release him from services attached to or allied with the armed forces. Perhaps it should not.

Difficulties attendant upon migration of population following the construction, operation and maintenance of war industries, have been confined quite largely to the smaller cities and to areas where sewerage was lacking or stream pollution hazardous. It can be stated with considerable pride that care has been exercised by the Army in protecting the environs of newly constructed cantonments and war industries by providing adequate sewerage for the new population. Both under the defense public works allotments and in the construction of independent facilities, the War and Navy Departments have exercised great care in avoiding possible health menace resulting from defense activities.

Sewage characteristics have changed to some extent because of speeding up of manufacturing processes and because limited administrative personnel has rendered impossible the inspection of tributary industrial wastes, the latter, a corollary of good operation in any sewerage system—particularly where bacteriological processes are involved. Manufacturing firms have grown careless and inconsiderate of the service that is being afforded by adequate sewerage. Constantly urged to greater production, they sacrifice most anything to operate at greater speed. Metal works, plating and pickling industries, packing houses, canneries, and allied food processing plants, are operating at unusual rates and sewerage is taking a pretty strong jolt because of lack of exercise of ordinary care in the plant waste disposal.

Public health is not yet in danger, nor is it believed that it will suffer greatly, from restrictions already imposed upon sewerage administrations. To a material extent sewerage improvements, particularly treatment works, are constructed and operated to prevent nuisance and not because of proven menace to health. Washington, with its vast increase in population, is contributing a pollutional load to the Potomac River, which may become a nuisance before the city's population is reduced or dispersed, but officials are said to see no opportunity for improvement of present conditions, and feel that the situation probably cannot be cured for the duration. It is noted that the Interstate Sanitation Commission considers important the order for nuisance abatement imposed against the City of Elizabeth, New Jersey, until materials of construction are again available. The State Department of Public Health of California has revoked the permit of the City of Los Angeles to empty sewage from its El Segundo treatment plant into Santa Monica Bay. There is no force to the order, however, because while the practice causes inconvenience, and is a nuisance, it is not a menace to health so long as bathers and fishermen do not enter the contaminated area, and consequently it is extremely doubtful that WPB will authorize any diversion of work or materials to its correction. Philadelphia, Camden, New York, Ottawa, the East San Francisco Bay Cities, and many others face similar situations. There will be some public discomfort for the next few years because of nuisances, but it is not conceivable that national authorities, guided in their thinking by the United States Public Health Service, will at any time permit sewerage conditions in this country to reach a situation where public health will be threatened. National health is deemed as essential as the production of arms and other war equipment.

The lure of high wages and short hours elsewhere than in the service under discussion will probably not take as many men away in the future as it has in the past because of the regimentation which national registration and the war Man-Power Commission are bound to impose. It may, however, be necessary to revert to a six- and in part even a 7-day work week to compensate for present and anticipated losses to the military forces if the work is to be adequately done.

One thing not heretofore mentioned but which apparently is consuming much time in training and preparation, is civilian defense against sabotage and bombing. This is an activity which cannot be lightly dismissed. It may, at some future time, be the basis of one of the most important functions of sewerage operation and maintenance forces, and in view of the potentialities involved, namely, the use of high explosives, demolition and incendiary bombs and poison gas, it does and will continue to take up a lot of time in training. It is an added duty to already overworked organizations but one which must be adequately met and accomplished.

So much for the events which have led to the present situation and its effect upon sewerage. From the record to date it is now possible to take a look at 1943 and subsequent years while we continue upon a war or national emergency basis.

What we have experienced to date, particularly in shortages of manpower, is only a patch to what the future appears to hold in store. Early this year the United States Employment Service stated that in 1942 employment on war production must increase from seven to seventeen million men, and it has been estimated that by the end of 1943 thirty million workers must be engaged in war industries. In round figures, there are less than sixty million workers in the United States. With eight or ten million in the Army, and thirty million in war industries, the remainder—twenty or twenty-two million, mostly second grade physically or beyond the age limit—must be prepared to accomplish all of the essential civilian activities of the nation. It is not difficult to conceive that by the end of 1943 instead of one in every eight members of the component organizations in the Federation being in the armed services or allied therewith, more nearly three in every eight will be there, because undoubtedly the need for men will be so pressing that all of the young or middle aged able-bodied will be taken. That will include about one-third of our members. Better than one in every four in this auditorium will probably be absent next year.

As to materials, there do not appear to be very many which can be taken from sewerage practice that are not already gone. Chlorination may be restricted to situations where public health or structural safety are involved; and it would be well for sewerage authorities to scan present chlorine use and be sure that this critical element is not being used unwisely. Building—excepting for repairs and wholly essential improvements—will stop entirely. If allowed at all, it will be of a temporary nature, to be replaced with more permanent work later. While public health will be protected, some nuisances are going to be created and tolerated, without hope of cure for the duration. Stocks and inventories must, and will, be brought into the open and used. Depleted entirely in some instances, and greatly reduced in others. They may even be commandeered. The national equipment inventory now makes it clear that WPB is going to make available for use where needed all heavy equipment that can be spared from civilian needs.

Approaching the possibility of invasion and or bombing, we must do so with the full knowledge that our ranks will be seriously depleted; that our problems will be more complex; our working hours longer; and our implements less. Early in this year, shortly after the declaration of war, General Hershey, Director of Selective Service, stated in part, "Each employer has the responsibility to secure and train replacements for men who are physically fit and would otherwise be available for military service." Casting about for a source of supply the thought occurs that it is not too early to consider seriously the use of female workers in sewage treatment plants, pumping stations, and the like. It is not at all difficult to visualize many of the operations in the very best of sewage treatment plants being done with female help. Man-power is the most serious problem which confronts us and it is a problem which cannot be solved by requesting deferment of men already engaged in sewerage works. Substitutes must be used just as in other departments of government.

The further one looks into the future, the more speculative becomes his predictions, but with the pattern of other wars behind us, and the magnitude of the current one in mind, is it difficult to conjecture that when we have won back our East Indian possessions and have assisted the other United Nations to re-assert their sovereignty in theirs; that when Japan has been ousted from China and backed into her islands once more; with India, Burma, Indo-China, Malay, Sumatra, Borneo, Papua, and all the vast multitude of Pacific Islands to police and fortify in conjunction with other United Nations—particularly Australia—is it difficult to conjecture that our Army and Navy will be many times its former peace-time strength, and that a flow of materials and equipment will continue into that area for years after the war is over?

This nation may have no desire for territorial aggrandizement, but if future wars such as this are to be avoided—that is, if we are not going to lose the peace, as has been said of the last world war—we, in conjunction with some of the other United Nations have a big job for many men in foreign lands for many years in order that peaceful governments may develop there. This means that not only will a large number of our troops not return immediately, but also that we—with England and her Empire—will be required to maintain a large Army and Navy for years after the war has been won. Such a situation will not be conducive to a free labor and materials market in the post-war period, excepting possibly in the first two or three years of readjustment to peaceful pursuits. Perhaps we will adopt the policy of recruiting an Army and Navy as other nations do, that is, by conscripting the nation's youth in classes for a period in the armed service, in order to maintain an adequate force of two—three—or possibly four—million men. That many taken out of the active physically best workmen will not leave us the freedom of action which we enjoyed three years ago.

The period of readjustment to peace time activities—during which many workmen may be unemployed awaiting return to former or newly learned occupations—should afford a golden opportunity for the construction of public enterprises presently postponed. During the national emergency, otherwise idle or not too busy design forces should be engaged in sifting proposed work, sorting out needful jobs in order of importance, and preparing plans therefor so that construction may proceed promptly upon the heels of war. Those who delay such planning may find themselves trying to build during the greatest boom the country has ever known with all of the disappointments attendant upon such a venture.

In thinking of the post-war era, one must not confuse it in his mind with such depression periods as 1932. It wasn't the immediate post-war era in the first World War which wrecked us—it was lack of control of a situation which developed from too much affluence as a result of post-war enthusiasm. It will probably be necessary that we adjust ourselves to thinking that restoration of peace will not entirely relieve our present difficulties.

Things aren't so bad now as they seem. A couple of years hence we will probably be looking back to October, 1942, as the "good old days." It is not a bad idea, however, to analyze the difficulties which beset us—see if we can anticipate others, and by so doing thwart in part their influence. Nothing is ever really very bad if one is prepared for it.

Discussion

By J. K. Hoskins

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The national emergency has exerted a profound effect upon our sewage treatment problems in this country, and, as we expand our war efforts, they will doubtless become more acute in many respects. Not all these influences have been adverse, however, and for the purposes of balancing the account, it may be helpful to enumerate some of both the good and the detrimental effects.

Detrimental Effects

The continued war effort is retarding the normal construction program of sewage plant building, both of new plants and improvement or enlargement of existing ones. This applies particularly to places not directly connected with the war effort. Increasing restrictions on the procurement of critical materials, particularly metals, have now reached a point where such construction is virtually impossible unless some concrete contribution to the war effort can be clearly proven. It is altogether likely that this deferment of construction will extend for an indefinite period into the future, because after materials again become available, financial problems will likely retard municipal improvements of this nature. Federal assistance in the form of public works programs may alleviate this post-war condition to a considerable extent.

The extensive shifts of civil populations to war industry centers have caused serious overloading of existing facilities in many places throughout the country. New federal and commercial housing projects have added large populations to existing sewerage systems and treatment plants, many of which have not been able to keep up with the rapid upward trend of sewage flows. The doubling and redoubling of housing facilities and war industries have made most difficult the economic design and construction of the added facilities required to handle these loads.

Contributions of large volumes of new types of industrial wastes have created perplexing treatment problems. In many instances, such new wastes have dominated or entirely changed the character of the raw sewage previously coming to disposal plants and upset the efficiency of treatment. As a result, many receiving streams are becoming more seriously polluted and forced to carry loads far beyond their capacities for recovery. It must be said, however, that some war industries, particularly the munitions plants, have endeavored to relieve these burdens by separate disposal methods. The Public Health Service, through the use of trailer laboratories located at representative plants, has assembled factual data on the nature and volume of waste to be anticipated from the manufacture of specific types of munitions. The information thus acquired is available to states and interested persons having to deal with these problems.

Trained operating personnel have been seriously depleted at many places as a result of the war effort. This shortage is likely to become more acute as time goes on because of the drying up of the sources of prospective trainees and professional workers. There appears to be no simple solution of this problem. The Selective Service System has hesitated to establish exempted lists of operating personnel in the sewage treatment field and the need for operators of Army plants has further reduced the number of experienced employees available to the municipalities. Failure of cities to increase compensation to such civilian employees has not improved this situation.

Beneficial Effects

One gratifying result of the national emergency has been the provision of adequate sewage treatment facilities at practically all of the military areas where material quantities of water carried wastes, either domestic or industrial, are created. The necessity of maintaining the safety of sources of public water supply and of avoiding overloading of streams by excessive pollution was generally appreciated by the construction forces of the military departments. In many cases, state health departments were active in stimulating interest in these essential sanitation problems and because of their accurate knowledge of local conditions, were able to advise concerning the specific requirements to be met in individual cases. Competent engineering personnel were engaged, accordingly, for the development and design of adequate sewage treatment plants fitted to the particular need of each individual military establishment.

Another beneficial result has been the provision of federal funds, through the terms of the Lanham Act, to construct and operate public works "in any area or locality where an acute shortage of public works or equipment for public works necessary to the health, safety or welfare of persons engaged in national defense activities exists or impends which would impede national defense activities, and where such public works or equipment cannot otherwise be provided when needed, or could not be provided without the imposition of an increased excessive tax burden or an unusual or excessive increase in the debt limit of the taxing or borrowing authority in which such shortage exists." The Act further specifies that as therein used "the term 'public work' means any facility necessary for carrying on community life substantially expanded by the national-defense program" and that the activities "shall be devoted primarily to schools, waterworks, sewers, sewage, garbage and refuse disposal facilities, public sanitary facilities, works for the treatment and purification of water, hospitals and other places for the care of the sick, recreational facilities, and streets and access roads."

Under this authority, urgently needed sanitation facilities have been or are being provided in many areas where the war activities have overwhelmed normal municipal functions. As of August 31, 1942, allotments of funds totaling over $43,000,000 have been made for 129 sewerage projects, 18 treatment plants and 73 projects comprising both sewerage and sewage treatment, so that 91 sewage treatment plants will be furnished. Of these allotted projects, 132 are under construction or completed, embracing a total of 67 sewage treatment plants, either separate or combined with sewerage facilities.

It is true, however, that some of these projects which earlier had been recommended for construction, have been deferred or revised in scope owing to changing conditions or to the increasing shortage of critical materials. It is likewise true that applications for the construction of many sewage treatment plants have been refused which in normal times should be built but which could not be approved under the limitations imposed by the Act. The net result, however, has been to provide sewage treatment in many instances where otherwise hazardous pollution would continue unabated.

OPERATION OF ARMY SEWAGE TREATMENT PLANTS *

By Lewis H. Kessler * and John T. Norgaard

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Last April the authors accepted the invitation of the California Sewage Works Association to prepare a paper on the above subject. In order to make available certain operating results of army sewage plants to a greater number of engineers, plant operators and health officials, permission was granted for publication of the paper in *This Journal,* July, 1942.

The first paper described the War Department administrative and personnel set-up as it then existed to maintain, repair and operate sewage works. The best available test data were shown from plants having competent operators who rendered reports to the Office, Chief of Engineers, in accordance with regulations. Since that time it has been possible for the writers to visit practically all of the plants and a number of others and in some cases a full year of operating results can be disclosed.

The objective of this paper is with as little repetition as possible to disclose further results of plant operation and bring the April paper down to date. More data and time have permitted a study of certain factors influencing design and operation, particularly in reference to high capacity filters. Some data and difficulties encountered in the contact aeration type of plants can be shown and discussed. Two chemical precipitation plants have also been placed in successful operation.

In the administration of the maintenance, repair and operation of the utilities there has been little change in personnel. The Repairs and Utilities Branch, Construction Division, Office Chief of Engineers, still is responsible for the budget work, policy formation and general supervision of plant operation and personnel problems as well as the approval of larger projects on alterations, extensions and betterments to the physical plants. Prior to May, 1942, the decentralization plan was set up with a District Engineer Office having jurisdiction of R & U work throughout each of the nine Corps Areas, Caribbean Defense Command and the like. This District Engineer office also carried out new construction work within a smaller geographical area. In May, 1942, to eliminate unnecessary channels for accomplishment of utility work, the responsibility for correlation of all work in the District was delegated to the U. S. Division Engineer Office, with the Division Engineer reporting directly to the Corps Area Commander. The Mountain Division took charge of the R & U work of that Division as well as the North Pacific and South Pacific Divisions. The Middle Atlantic Divi-

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

sion Office was created and the South Atlantic Division Office moved from Richmond, Virginia, to Atlanta, Georgia. In the near future the Southwestern Division and Ohio River Division Offices will probably be moved to the city having Service Command Headquarters.

On July 15, 1942, the basic reorganizational directive took effect. The Corps Areas became the Service Commands. Under this reorganization the Division Engineer has been placed on the Staff of the Service Commander as Director of Real Estate, Repairs and Utilities. All directives pass through the Service Command. The Services of Supply Organization Manual includes Army Regulations No. 100–80, revised August 10, 1942, on Repairs & Utilities. The regulations include the assignment of responsibility at Army Posts within the Continental United States, authority for emergency work, annual estimates, request for funds, distribution of funds, military and civilian personnel, records and reports, accountability, purchasing and contracting, construction and maintenance, equipment and special purpose vehicles and channels of communications.

The Tentative Repairs and Utilities Regulations comprising Chapter XII, Orders and Regulations, Corps of Engineers, were revised on July 28, and several revisions have occurred since then. Duties and responsibilities have been clarified as based on some seventeen (17) months' experience all in keeping with a decentralized policy. The regulations carry a provision setting up the sections of the Division Engineer Office similar to those in the Office Chief of Engineers. Greater stress has been placed on close contact of the officers and engineers of Division Offices with the Posts to "shoot trouble" rather than "trouble shoot." Authority for recommendation and action is being decentralized to save time, reduce paper work and permit the engineer, if he is competent to make the field study originally, to cause the necessary action to be initiated.

Since the authority for new construction by the Corps of Engineers does not rest with the Service Command, a policy has been established which is as follows: When the Area Engineer certifies that construction and utilities of military cantonments is complete and the Division Engineer takes over the operation of the post, no arguments ensue as to whether the job is completed or not, although some deficiencies may be filed. If construction is found unsatisfactory, it is the task of R & U (the Post Engineer) to alter the physical plant so it will function properly; Engineer Service Army funds are used for this work. In the present fiscal set-up the Office Chief of Engineers authorizes expenditure of funds allotted to the Division Office for non-recurrent items above $10,000. Recurring items are administered entirely within the Division Office.

The R & U Branch, OCE, is continuing engineering investigation on special operating problems common to or confronting a number of posts and rendering technical assistance to the Division Offices when requested. Every effort is being made to operate the Washington Office with a small number of officers, engineers and professional men.

Design Factors and Units

There have been no recent changes in the design factors or units of sewage plants. The major change in designs have been caused by directives relative to conservation of critical materials. No policy of standardization of design has been effected except in the case of the wooden Imhoff tanks and high capacity trickling filters for the 3600 population camps to be activated by prisoners only. Outside of the siphon chamber and first quality rotary distributor, this design uses no critical material, not even reinforcing steel, or metal valves. Where necessary, chlorine will again be relied upon for sterilization of the effluent.

Operating Personnel

Due to the labor problems confronting those in charge of Army Post utility work, an upward revision in wages of all non-professional workers became necessary. Sewage plant personnel were included. Tables I and II show the suggested maximum salaries for the workers of the four classes of plants. In general overtime pay has increased the wages about 20 per cent. Where professional engineers are shown, it should be recalled that these men are placed in charge of operation of the water works and distribution system as well as sewage treatment and the collection system.

Table I.—*Classification of Sewage Treatment Plants*

Sewage Treatment Plant Types	Classification			
Post or Contributory Population	38,000 and over	12,000 to 38,000	6,000 to 12,000	1,500 to 6,000
Complete Treatment with Separate Sludge Digesters	A	A	B	C
Primary Tanks and Separate Digesters—Primary Treatment Only	A	B	C	C
Doten or Imhoff Tanks with Trickling Filter	B	B	C	D
Doten or Imhoff Tanks Only or Sand Filters Only	—	—	D	D

Indications are that because of Selective Service it will be increasingly difficult to obtain the services of assistant and associate sanitary engineers and plant operators. We are opposed to classifying men as Sanitary Engineers who do not meet with the correct meaning and intent of the title. It may be that competent men with years of experience in both water and sewage problems will be employed in a favorable pay bracket but with a sub-professional title or unclassified civil service rating. At the discretion of the Division Engineer, certain deserving key personnel formerly in the employ of the War Department, upon induction into the service may be given a letter requesting that the inductee be assigned to an officers' training school, if qualified, or that he be assigned to such arm or service for which he has been working. The inductee would be dispatched to a replacement training center of that branch or a unit requiring his civilian specialty. Responsibility for presenting such a letter rests with the individual. The objective is to

TABLE II.—*Civilian Personnel for Sewerage at Army Posts*

Section	Designation	Class	Base Pay	38,000 and Over		12,000 to 38,000		6,000 to 12,000		1,500 to 6,000	
				No.	Annual Cost	No.	Annual Cost	No.	Annual Cost	No.	Annual Cost
Sewerage and Water Supv.	Sanitary Engineer	P-4	$3800	1	$3800						
	Assoc. Sanitary Engineer	P-3	3200			1	$3200	1	$3200	1	$3200
Sewage Pumping and Treatment Plants	Class "A"										
	Plant Supervisor	Uncl.	3000	1	3000	1	3000				
	Jr. Chemist	P-1	2000	1	2000	1	2000				
	Sewage Equip. Oper.	Uncl.	2100	4	8400	4	8400				
	Class "B"										
	Plant Supervisor	Uncl.	3000	1	3000	1	3000	1	3000		
	Sewage Equip. Oper.	Uncl.	2100	4	8400	4	8400	4	8400		
	Class "C"										
	Plant Supervisor	Uncl.	2800					1	2800	1	2800
	Sewage Equip. Oper.	Uncl.	1860					4	7440	4	7440
	Class "D"										
	Sewage Equip. Oper.	Uncl.	2100					1	2600	1	2100
	Plant Worker	Uncl.	1500					1	1500	1	1500
Sewers and Water Distr. System	Inspector	Sp-6	2000	2 *a	4000	1 *b	2000				
	Sr. Foreman of Const. and Maintenance	Uncl.	2600	1 *a	2600						
	Foreman of Const. and Maint.	Uncl.	2300					1	2300		
	Jr. Foreman of Const. and Maint.	Uncl.	2100	1 *a	2100	1 *b	2100			1	2100
	Classified Labor	Uncl.	1320	3 *a	3960	2 *b	2640	2	2640	1	1320

(*a 24,000 or over) (*b 12,000 to 24,000)

secure maximum use of the specialized skills possessed by men particularly in water and sewage plant operation.

The Army Specialist Corps is being very cooperative in obtaining men to perform sanitary engineering functions. At the present time it is contemplated that men will be commissioned in the Corps for service at the larger posts requiring the services of men skilled in sanitary work. Supervision of tasks connected with satellite airfields would also be included.

A number of Sanitary Corps officers are trained sanitary engineers. At many posts these men have rendered valuable assistance not only in recommendations for improvements but in actual training of plant operating personnel.

Securing competent personnel and continuity of service in the Office, Chief of Engineers, Division Engineer Offices and at the Posts is one of the pressing problems facing our portion of the work of the Services of Supply. The Service Command has tasks comparable to those of a hotel manager with the tactical units being his guests. With the ever-increasing Army, proper utility service must not be permitted to break down due to inferior or inadequate personnel.

Some Recent Operating Problems

Grit.—The quantiy of grit at most of the newer cantonments has in general decreased with continued use and repair of the new collection system. However, in a number of plants it has been necessary to construct grit chambers to reduce trouble in the primary clarifiers, wear on the comminutors and later difficulties in separate sludge digesters.

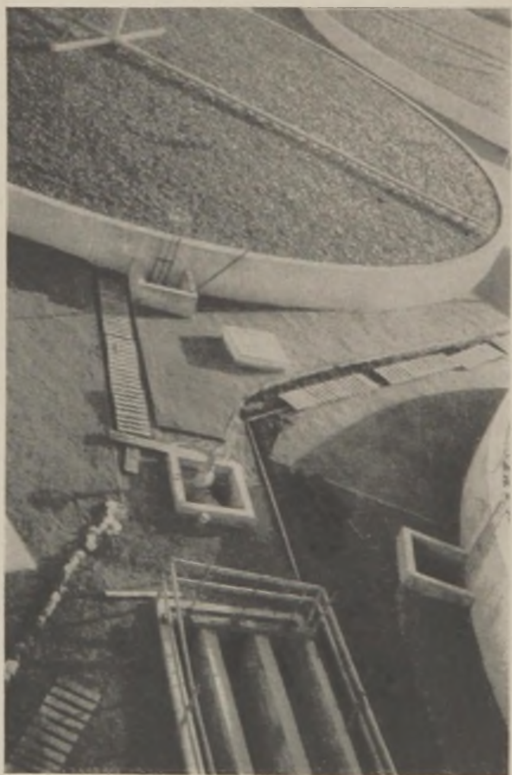

Fig. 1.

One serious maintenance problem facing several posts on both the east and west coast is the disintegration of the rock of the trickling filters. Figure 1 shows an installation of deep grit chambers between the filters and final settling tank to collect the mineral particles and eliminate clogging of discharge pipes from the final tanks. The chambers are cleaned monthly and during the past four months the construction has proven invaluable, even though it is a radical departure from accepted practice.

Grease.—Operating reports at many posts show that the grease trap rehabilitation program and grease salvage has eliminated grease problems of filter operation. When the cleanout-type flow control tee (see Figure 2) has not been placed ahead of the grease traps, or an unvented

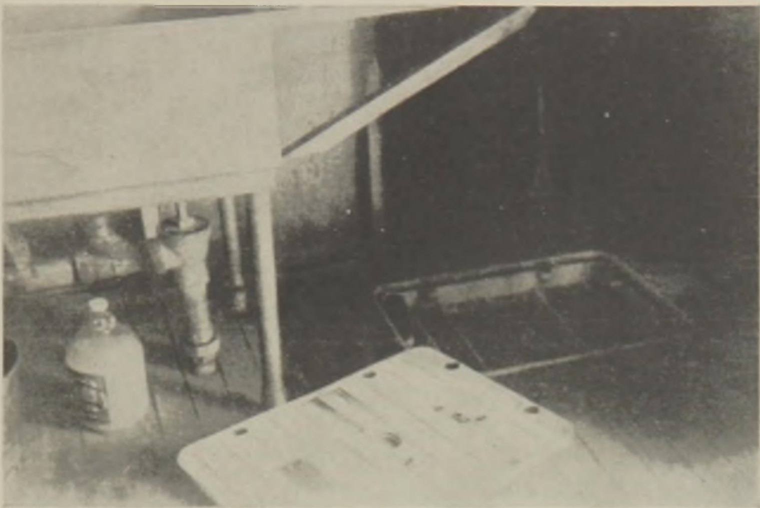

FIG. 2.

siphon leg has been created by locating the ceramic traps below the mess hall floor, grease collection has not been satisfactory, and grease at the primary portion of the plant is still troublesome. At some posts where a definite schedule is not followed in cleaning the traps after the 50-pound retention capacity has been reached, plant operators still report grease troubles both in the sewers and at the plant. Figure 3 shows an accumulation at a Texas plant one hour after cleaning the channel and clarifier surface. It is found that where Sanitary Corps officers thoroughly understand the problem and company commanders follow their suggestions, the officers report that the trap grease collection and removal is satisfactory. The reports of officers who had similar duties in World War I particularly confirm this conclusion. Some 120 of the most important posts have been visited by an engineer experienced in grease trap problems of both design and installation and in most cases an improvement in grease collection has been observed after his instructions have been followed.

The Salvage Branch of the OQMG states that approximately six million pounds of grease are being salvaged each month. This amount includes interceptor grease along with the frying fats and other kitchen fat wastes. This grease will produce 600,000 pounds of glycerine which is converted to an equal weight of nitroglycerine. Incidentally, the collected grease, being free from sewage solids, is highly desirable.

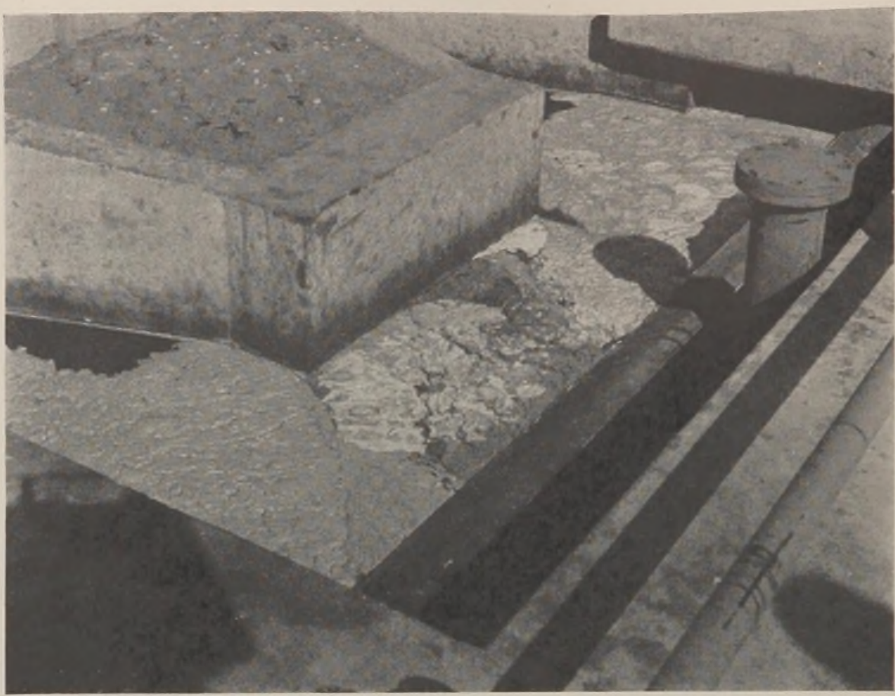

Fig. 3.

Hydraulics of two mechanical aeration type grease collectors at a new Alabama post are being changed and the Post Engineer expects collection at the surface to be improved.

Filters

Recent surveys have shown that in a number of posts the rock on the filters has been placed improperly during construction. At one post where the stone was so poor it could not be accepted, upon removal it was found that 80 per cent of the underdrains were completely clogged with small stones and sand and 40 per cent of the underdrains had been either crushed or split open, probably due to direct fill by a bulldozer. In a few plants it is still questionable whether the larger rocks were placed carefully over the channels in the underdrains.

The disintegration of the rock in the West Coast filters may be because the stone may have not been accustomed to moisture for many years but in several cases the specifications were not complied with, other than meeting delivery dates, and original size of stone.

At some high capacity filter plants it is manifest that the filters are of "hybrid" design and no manufacturer will claim them as a design he would advance, nor will he assume responsibility for failure to produce anticipated results. To avoid this situation the following recommendation has been made to Architect-Engineers and District Offices: "Where it is determined that the use of high capacity filters will result in economies, it is suggested that the design data set forth in this communication be strictly followed and that the manfacturers' recommendations on the required equipment and processes be followed. This will make it possible to fix responsibilities and require guarantees covered by performance bonds.''

Sludge Digestion

On the West Coast are found some multi-stage digestion tanks (Figure 4) constructed of steel before this material became critical. They

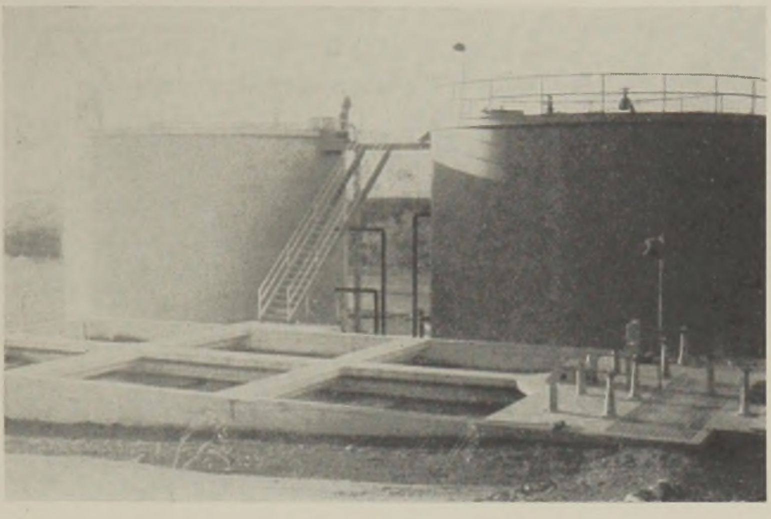

Fig. 4.

have been quite successful after being repaired to make them water tight at the foundation, but due to heat losses temperatures are difficult to maintain. Most tanks are of concrete and some have the dome type construction as in Figure 5.

An unsolved problem at a number of posts is the treatment of the supernatant liquor prior to return to the primary settling tank. Experiments to date on a full scale vacuum type aerator (Fig. 6) show that at this southern post the capacity of digesters can be increased and the strength of the supernatant reduced at a nominal cost with little operating difficulty. The device reduced the total solids in the effluent to about 1100 p.p.m. regardless of the initial solid content, which varied from 1300 to 14,000 p.p.m. Suspended solids in the supernatant varied from 250 to 450 p.p.m. and B.O.D. of the treated supernatant varied between 110 and 425 p.p.m., with an average of about 200 p.p.m. Dissolved oxygen was always present.

The unit worked well by either batch or continuous feed and no chemicals were required. At another post a supernatant treatment tank has been constructed, in which lime is added to bring pH above 9.0. Without pretreatment, the supernatant liquid disposed of on sludge beds has eventually clogged them and in some places has caused heavy algae growths.

A slotted well-strainer type of device erected vertically in the digestion tank is now operating at four plants. Drawoff of supernatant at

Fig. 5.

Fig. 6.

the proper level occurs where the concentration of the solids is the least, because the slots clog where the sludge is thick. The device saves critical valves and fittings as well as the time of the operators. Provision is made for back flushing to remove clogged material without causing a cross-connection.

Land disposal of digested sludge by use of a "lemonade" wagon is still under study. A report of the Post Surgeon is awaited to see if the practice will be continued. Whether hookworm and pathogenic organisms are found for any length of time in the thin sludge flakes after exposure to the sun is now being studied.

Unheated digesters and lack of provision of heating coils is the cause of the greatest trouble in digester operation. Regardless of the size of the plant, we are of the opinion that the most certain and economical solution to this problem is heat. Cold digestion tanks are designed at double the capacity but operators have little control and cannot raise temperatures to reduce scum formation. One post is preparing to heat primary sludge with live steam before discharge into the di-

FIG. 7.

gester. Even in the South and Southwest, there are long periods where digesters are exposed to temperatures well below that of the incoming sewage.

The problem of the "blackout" of the flare from waste gas burners will have to be met by many cities as well as Army posts. Figure 7 is a view of a 24-inch diameter corrugated iron chimney at a West Coast plant, with covered top about 8 feet above the burner. A service door is located at burner elevation. Army pilots and the Post Engineer report the design is satisfactory.

Nineteen posts have Imhoff tanks, thirteen of which are of recent construction. Those in the southern Air Corps stations followed by sand filters are producing particularly good results. All but one of the treatment plants in the New England Division are Imhoff. The distribution is not limited to warmer climates. Figure 8 is a circular Imhoff

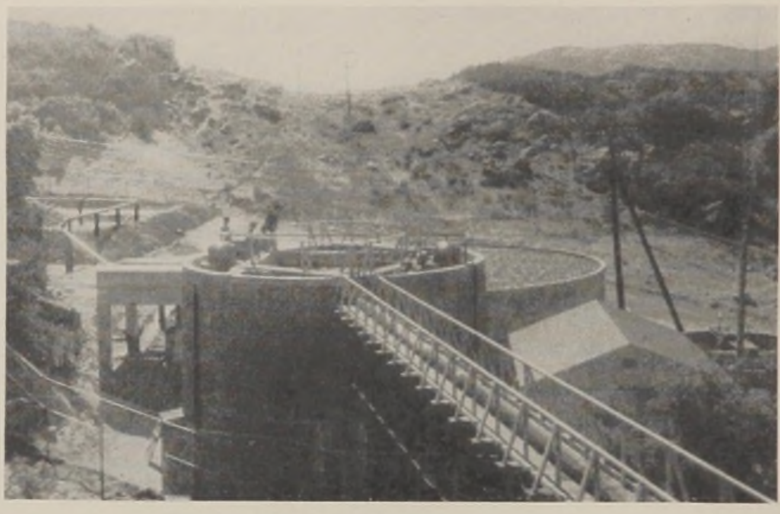

Fig. 8.

tank followed by a standard rate filter at a post on the Mexican border. In spite of the good effluent and final chlorination, due to the international aspect, the effluent is now lifted over the hill for dispersion on the ground with final disposal as seepage and evaporation.

Activated Sludge

With one exception, all activated sludge plants are east of the Mississippi. All but two plants have been operating satisfactorily and considerable more operating data could be shown. In one of the two plants chlorination of the return sludge at the division box has eliminated bulking trouble. In the other plant, chlorine is dosed into the mixed liquor prior to final settling but the effluent is not so clear as where the chlorine is used in the return sludge. It is reported that microscopical examinations of sludges from Army plants do not disclose the variation in organisms found in many municipal plant sludges.

Contact Aeration (Hays Process)

About 63 contact aeration plants with two-stage aeration and intermediate settling have been or are being constructed in this country, of which the Army has 27 with design capacities from 2,500 to 40,000 population. They are located in the Fourth, Seventh and Eighth Service Commands. Very few are designed alike and we have been trying to discover the best method for operating these plants. During the past year some of the original claims set forth by the proponents of the process have been abandoned, operating instructions are continually revised, and suggestions to designers are changed.

Originally the plants were small, under 5,000 population. The designs were suddenly jumped to 26,000 and then to 40,000 without adequate operating data with Army sewage, including laundry flow and digester supernatant liquid return. It has been impossible to determine the correct design units based on seasonal behavior or to anticipate fully the mechanical difficulties likely to be encountered. Operating reports show only four plants are giving continuous performance in accordance with expectations. In the smaller plants the benefit of laboratory control was not fully realized because in general none was provided. This has handicapped the work of the U. S. Engineer offices as well as the operators. On the other hand, without a junior chemist so much of the operator's time is consumed in valve operation, sludge pumping and plant routine that he has little time for conduct of standard control tests. The third largest plant, where useful data might have been obtained in time, was forced to try to carry a 35,000 population load on a 26,000 population design without any capacity factors. The plant was so urgently needed that operation of each unit began as soon as each tank was completed over a six-week period. Without laundry waste and digester supernatant the growth on the plates improved but this plant is beset with mechanical failures at most inopportune times.

Figure 9 is a view of the largest plant. Figure 10 shows the first-stage aerator and Fig. 11 the second-stage aerator. Figure 12 is a top view of the upper section of vertical transite plates partially uncovered for inspection by dewatering the tank. Corrugated plates are no longer recommended. Wooden spacers have been added to keep the plates in line and resting for most of their length on the plates of the lower section. The air-diffuser pipe grid is located underneath the plates but above the chain-type sludge concentrator. In the smaller plants, hopper bottoms are used for sludge concentration rather than a mechanism. These hoppers cannot be squeegeed. Mechanical equipment failure, with subsequent dewatering of aeration tanks, causes quick death of the organisms in the mat clinging to the plates. This mat requires several weeks to develop. There exists no way of keeping the flora alive as in activated sludge plants having more than one aeration tank.

The best method of supporting and clamping the plates, holding the spacing and keeping them from bending, has not been found. It is not known just how to keep the pipe grid from clogging so that dead spots will not appear periodically in the aerators. Return of material sloughed from the plates (sludge) is not practiced because in some places it has caused clogging of the bottom of the space of the lowest plate section. In one plant a "cardinal" colored bacterial growth appeared on the plates, probably of a facultative type. No dissolved oxygen was being maintained in the tank mix. Underneath the beams where sunshine could not reach the plates, these organisms were not observed. Gradually the greenish-brown mat or flora was built up. This seems to grow first in the second stage and develops last in the first stage.

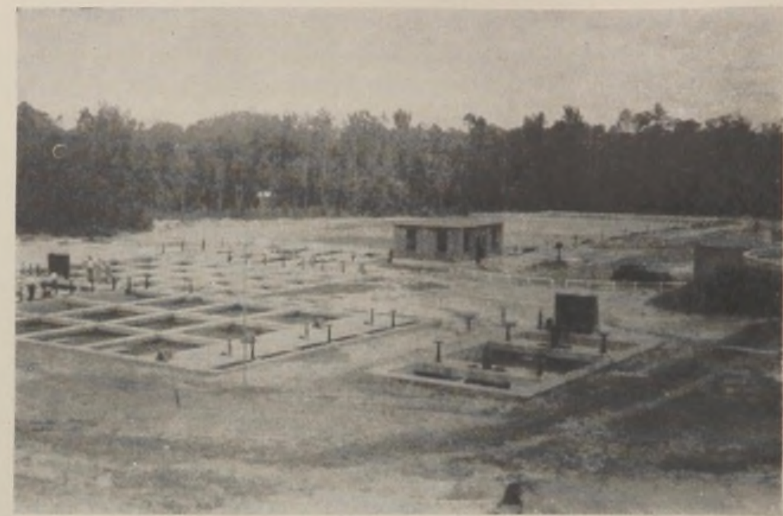

FIG. 9.

FIG. 10.

We have not sufficient evidence to disclose whether the organisms in the second stage differ from those in the first stage. At one plant in addition to hydrogen sulfide odor, a pungent odor like sulfur dioxide was noted. Accumulation of sludge below the plates for a period greater than from 3 to 4½ hours is apparently very detrimental to the maintenance of proper life on the plates. Without liming the digester supernatant there is evidence that return of this liquid is too great a shock load on the plant. Whether the plants can treat laundry waste without pretreatment or holding tanks remains to be disclosed.

Captain Leroy H. Scott of the Fourth Service Command operates by giving all the air to the first stage for from 24 to 36 hours or until

FIG. 11.

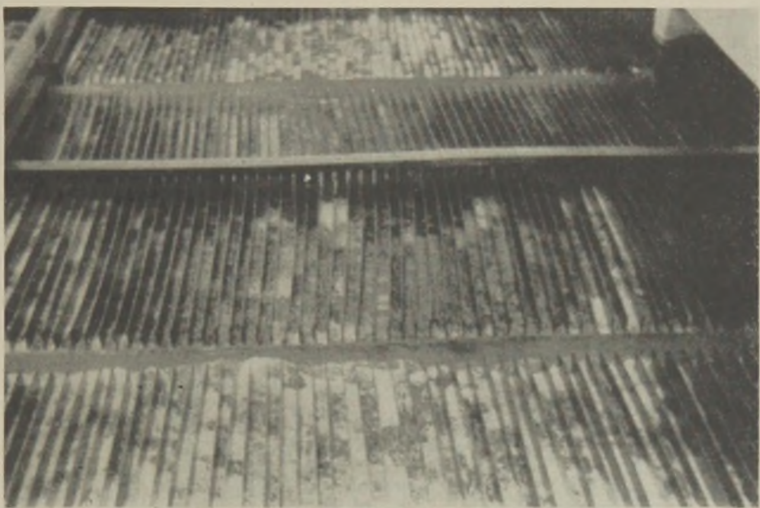

FIG. 12.

dissolved oxygen is present, and then gradually equalizing the air between the first and second stage. Indications are that the contact aeration plants will require more than the 1.5 cu. ft. of air per gallon (design unit) not only in the beginning but continuously. It may be that elimination of mechanical equipment underneath the plates and substituting ridge-and-furrow type air diffusers will improve plant operation, eliminate present pipe grid troubles as well as prevent aerator shutdowns.

There is one fact that may vitally affect the functioning of the Hays process. Mr. Hays always maintained he desired a short detention period in the primary tank. The capacity factors now in use by the Army to care for increased populations at posts, prohibit short detention periods when the discharge is not up to the design factor. It is possible that a shorter primary settling period or fine screening only might aid in plant performance.

Operating Results

It became apparent as early as July, 1941, that steps to conserve water would have to be taken, not only to save water but to reduce the sewage flow at plants, otherwise the design flow capacity would be exceeded even though B.O.D. load might not be. Hydraulic engineers were employed by each Service Command and provided with water leak detection apparatus and station wagons. These engineers also make

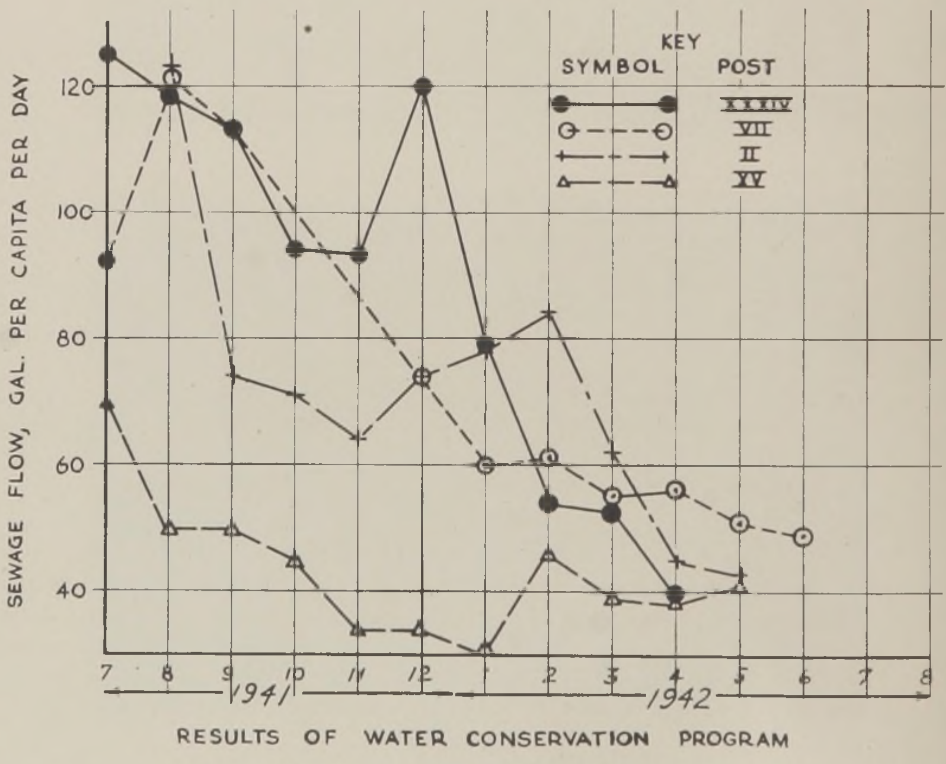

Fig. 13.

surveys of water waste and recommend installation of urinal flush valves, correction of leaky valves, better use of refrigeration cooling water and use of auxiliary supplies for vehicle and aeroplane washing. The results have been gratifying. Figure 13 shows what has been accomplished in reduction of sewage flow at four posts by water conservation. Results are in general comparable except for the smaller posts and air corps stations. Figure 14 shows the per capita sewage flows in December, 1941, compared to June, 1942, in 35 and 44 posts respectively. The trend in sewage load is definitely downward, and even including laundry wastes, indications are that by continued conservation activity on the part of the Post Engineers' staff, the sewage flow can be held to about 70 gallons per capita per day, the original design unit.

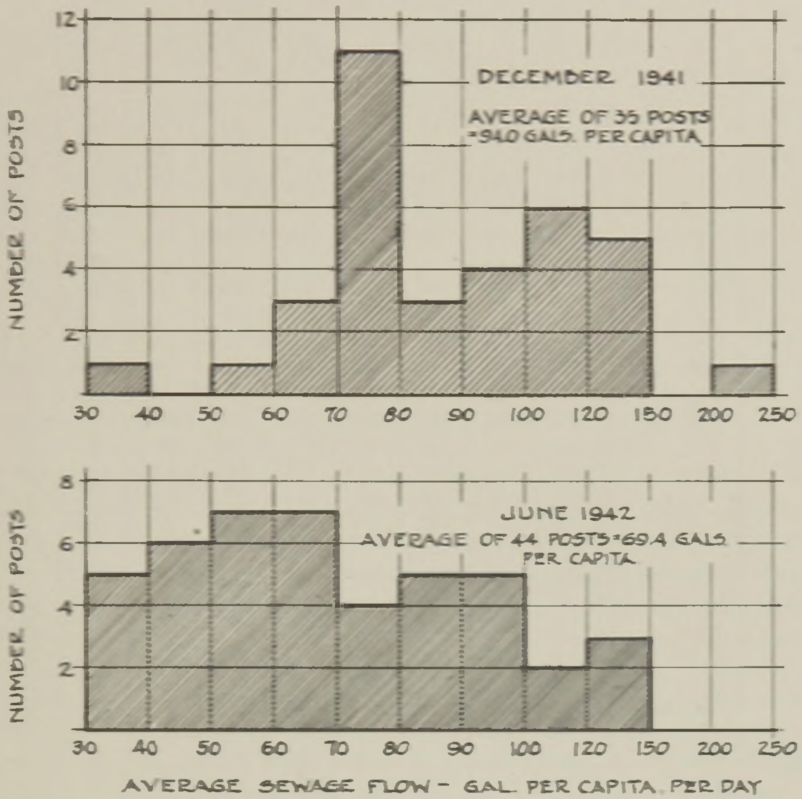

Fig. 14.

Prior to the declaration of war, the posts were not activated beyond design capacity. Water conservation alone cannot care for increase in population but a recent survey (July, 1942) indicated about 75 plants would need to be altered, extended or bettered. Further investigation reduced this figure to 25 or less requiring major improvements to provide treatment efficiencies adequate for the duration, providing chlorination of the effluent is continued. Chlorination in winter has been abandoned at many stations, because of the good operating results.

Plant Data

Tables III to VII are included to bring up to date the results of plant operation disclosed for the first time in the July, 1942, issue of *This*

Journal in identical table numbers. The comments made therein in general apply now. In Table V, Post XXVII, the marked decrease in sewage flow due to installation of urinal flush valves forced a radical change in plant operating routine. It is believed these data used to

TABLE III.—*Operating Results—Primary Treatment*

Post and Designed Capacity	Month	Con-tribu-tory Pop.	Aver. M.G.D. Flow	Flow—Gal./Cap./Day	Average B.O.D.		Aver. Susp. Sol.		% Reduction		Aver. Detn. Hours
					Raw	Effluent	Raw	Effluent	B.O.D.	Susp. Sol.	
II	Previous										
3.5 M.G.D.	Average	30,836	2.41	81	113	81	169	72	28	56	3.7
50,000	March	50,477	3.13	62	164	131	204	98	20	52	4.2
	April	54,797	2.49	45	169	144	192	107	15	44	5.3
	May	50,106	2.13	43	166	150	223	124	10	44	6.2
	June	39,059	1.75	45	153	130	326	108	15	67	7.3
	July		0.97		164	111	349	76	32	78	13.2
	August	21,373	1.02	48	127	103	299	76	19	75	12.0
XVIII	Previous										
1.4 M.G.D.	Average	18,943	1.59	83	229	163	185	91	28	51	2.7
	March	22,167	1.71	77	271	219	176	88	19	50	2.5
	April	21,838	1.35	62	313	254	228	100	19	56	3.2
	May	19,464	1.16	60	460	358	280	105	22	63	3.7
	June	23,343	1.43	61	490	372	266	102	24	76	3.0
	July	25,761	1.58	61	409	310	227	103	24	55	2.8
	August	23,531	1.58	67	433	303	228	105	30	54	2.8
XXXV	February	30,066	1.84	60	560	400	978	199	29	75	5.5
23,000	March	30,211	2.08	69	450	305	646	150	32	76	4.9
	April	28,236	2.09	74	356	256	347	164	28	52	4.9
	June	29,502	1.35	46	412	320	443	181	22	59	7.5
	July	37,601	1.55	41	550	272	403	164	50	59	6.6
	August	41,590	1.62	39	553	297	550	222	45	59	6.3
XXXVI	May	7,788	1.06	137	223	165	192	93	26	52	2.1
	June	8,547	1.11	130	193	145	151	94	25	38	2.2
	July	9,100	1.05	115	182	132	141	85	28	40	2.1
	August	10,675	1.08	101	169	119	162	99	30	39	2.1
XXXVII	May	8,309	1.32	168	188	87	184	101	54	45	3.2
	June	10,860	1.33	123	122	81	173	92	34	47	3.2
	July	11,021	1.30	121	153	101	162	85	34	48	3.2
	August	11,045	1.27	114	140	84	171	85	40	50	3.3
XI	November	11,875	1.00	84	483	168	393	86	22	40	1.7
	December	5,257	0.56	107	497	346	239	112	30	53	3.0
	January	3,079	0.43	139	287	180	147	90	37	39	3.9
	February	2,777	0.37	133	209	175	131	47	16	64	4.6
	March	3,682	0.42	113	336	163	96	42	43	43	4.0
	April	4,919	0.55	113	253	144	115	57	45	44	3.1
	May	4,687	0.55	118	212	159	92	71	25	23	3.1
	June	6,162	0.46	74	293	212	144	104	28	27	3.7
	July	5,788	0.46	70	315	211	170	93	33	45	3.7

Table IV.—*Operating Results—Standard Filters*

Post and Designed Capacity	Month	Con-tribu-tory Pop.	Aver. M.G.D. Flow	Flow—Gal./Cap./Day	Average B.O.D.		Aver. Susp. Sol.		% Reduction	
					Raw	Effluent	Raw	Effluent	B.O.D.	Susp. Sol.
XX	Previous									
3.0 M.G.D.	Average	32,680	2.44	78	275	53	201	51	79	74
	April	35,053	2.36	67	277	57	135	50	79	54
	May	37,686	2.19	59	277	45	124	33	84	74
	June	32,500	1.815	56	281	53	190	42	82	78
	July		1.505		266	49	194	33	82	83
XXIII	Previous									
1.4 M.G.D.	Average	14,274	1.17	82	173	11	194	16	92	91
	March	15,413	1.14	74	275	13	94	16	95	83
	April	15,287	1.28	84	195	12	116	18	95	89
	May	18,600	1.31	71	211	12	112	31	94.5	73
	June									
	July	14,950	1.32	88	173	8	117	25	95	79
XXXVIII	June	11,076	1.42	128	180	34	168	33	81	80
0.56 M.G.D.	July	9,859	1.28	114	142	19	179	30	87	83
10,000										

construct some of the following charts holds particular interest because seasonal operation as well as widely distributed climatic conditions have faced the various plant operators. Since the characteristics of the various army post sewages are comparable, perhaps more so than that of municipalities and due to maneuvers and fluctuations in populations not found in cities, it is possible to analyze the high capacity filter plant results at various loadings.

Figure 15 is a plotting of several months average operating data showing per cent B.O.D. removal (overall) in single-stage biofilters, compared to the pounds of B.O.D. loading in raw sewage, per day per acre foot of stone. Assuming 40 per cent of B.O.D. removal in the primary, as required by the OCE Design Manual, a loading of 5,000 pounds B.O.D. per day of raw sewage is equivalent to the design unit of 3,000 pounds applied per acre foot per day. The single-stage biofilter plants apparently perform with an expected removal of about 85 per cent B.O.D.

Figure 16 shows a plotting of monthly average operating results for four aerofilter plants. Most of the results are at design load or less according to the 5,000 pound B.O.D. unit. These results show a wide range from about 60 to 83 per cent B.O.D. removal can be expected with an average removal of about 70 per cent at the design loading.

Two-Stage Biofilters

Figure 17 shows the monthly average operating results on five two-stage biofilter plants. All but one of the plants have been overloaded

TABLE V.—*Operating Results—Single Stage High Capacity Filters*

Post and Designed Capacity	Month	Contributory Pop.	Aver. M.G.D. Flow	Recirculation Ratio	Flow—Gal./Cap./Day	Average B.O.D.		Average Susp. Sol.		% Reduction	
						Raw	Effluent	Raw	Effluent	B.O.D.	Susp. Sol.
VII	Previous	18,043	1.54	3.8	86.8	296	95	188	76	68	61
3.0 M.G.D.	Average										
30,000	March	18,850	1.05	4.85	55	395	84	248	73	79	71
Bio-filter	April	19,000	1.06	4.91	56	441	77	268	69	83	74
Imhoff Prim.	May	17,377	.89	5.38	51	445	45	306	65	90	79
	June	18,847	.93	4.93	49	405	33	279	32	92	89
XXII	January	62,410	3.85	2.6	62	360	43	245	42	88	83
4.62 M.G.D.	February	64,097	4.04	4.62	63	311	87	245	50	72	80
65,000	March	65,199	5.06	2.91	78	310	49	204	38	84	81
Bio-filter	April	63,351	4.95	4.04	78	299	49	199	23	84	88
	May	68,008	5.00	3.74	73	310	49	207	30	84	86
	June	69,031	4.85	4.57	70	323	42	192	28	87	85
	July	67,327	6.39	3.00	95	283	47	198	38	83	82
	August	67,604	6.90	2.76	102	301	56	215	37	82	83
VIII	Previous		1.90			213	51	187	35	77	79
2.0 M.G.D.	Average										
28,500	March	21,578	2.58	0.26	120	242	68	172	62	72	64
Aero-filter	April	22,563	2.26	0.40	100	216	48	137	41	78	70
	May	26,199	2.50	0.32	96	194	60	96	40	69	58
	June	26,717	2.08	0.54	77	197	39	151	44	80	72
	July		1.56			262	47	239	47	82	80
	August		1.71			323	63	290	59	80	79
XIV	Previous	16,152	1.295	2.14	81	204	12	348	10	94	97
1.4 M.G.D.	Average										
20,000	March	29,918	1.94	1.27	65	340	54	293	31	84	89
Bio-filter	April	33,350	2.38	1.03	71	194	44	178	46	77	74
	May	30,648	1.57	1.62	51	137	34	269	42	75	84
	June	33,375	1.95	1.42	43	193	41	207	46	79	78
	July		1.83	1.60		216	55	196	44	75	78
	August	23,817	1.54	2.02	64	182	30	189	35	84	82
III	Previous	17,953	2.78		165	207	46	145	26	78	83
2.1 M.G.D.	Average										
30,000	March	31,002	3.50		113	200	70	196	47	65	74
Aero-filter	April	31,984	3.52		110	210	63	194	54	70	72
	May	31,446	3.81		121	158	41	203	45	74	78
	June		3.97			179	34	204	41	81	80

at times. Indications are that at the 5,000 pounds B.O.D. applied loading, these plants will give between 80 and 90 per cent B.O.D. removal with an average about 85 per cent.

In comparing average results of Figures 15 and 17, it is observed that the single-stage and two-stage biofilter plants treat Army sewage with about the same per cent B.O.D. removal at design loading. This appears reasonable, because in the case of the two-stage plant about 85

Table V.—*Continued*

Post and Designed Capacity	Month	Contributory Pop.	Aver. M.G.D. Flow	Recirculation Ratio	Flow—Gal./Cap./Day	Average B.O.D.		Average Susp. Sol.		% Reduction	
						Raw	Effluent	Raw	Effluent	B.O.D.	Susp. Sol.
I 1.4 M.G.D.	Previous Average	14,176	1.435		97	203	94	214	41	54	80
20,000	March	28,981	1.65		57	199	77	205	55	62	73
	April	26,272	2.09		80	258	126	213	87	51	59
	May	25,796	1.89		73	296	92	192	67	69	65
	June		1.75			295	101	180	48	62	73
	July		2.12	0.05		316	66	145	40	68	72
	August		1.84			275		188	Operation disrupted due to construction		
XXVI	November	9,228	0.61	1.0	66	318	52	274	56	84	71
0.7 M.G.D.	December	7,037	0.58	1.5	79	303	41	465	52	86	89
10,000	January	6,805	0.65	1.3	96	275	48	321	45	83	80
	February	8,815	0.62	1.4	71	302	48	317	51	84	84
	March	9,224	0.71	1.2	77	262	40	384	41	84	81
	April	10,287	0.74	1.2	73	271	54	241	52	80	78
	May	8,815	0.70	1.2	77	303	49	189	52	84	72
	June		0.57	1.5		255	35	256	54	86	80
	July	9,100	0.56	1.6	62	327	44	219	55	86	75
XXVII	October	2,550	0.16		63	388	60	209	35	82	83
0.25 M.G.D.	November	2,000	0.13		67	244	61	235	33	75	85
Aero-filter	December	1,750	0.12		71	233	41	220	36	83	84
	January	1,750	0.11	0.2	66	204	51	195	31	85	84
	February	2,191	0.22	0.1	102	178	41	208	39	77	81
	March	2,486	0.25	0.1	100	200	51	117	27	77	77
	April	3,903	0.18	0.1	45	395	75	316	52	81	80
	May	4,588	0.17	0.2	37	471	88	387	61	81	84
	June	3,770	0.18	0.2	49	430	80	295	41	81	80
	July	5,179	0.23	0.2	44	435	83	243	64	78	70
XXVIII	January	2,455	0.17	0.3	69	323	52		37	84	
0.25 M.G.D.	February	3,943	0.19	0.2	49	293	148	428	35	49	92
Aero-filter	March	3,750	0.16	0.3	43	270	62	304	27	77	91
	April	3,691	0.17	0.5	47	391	112	312	57	71	85
	May	4,171	0.17	0.5	41	381	118	315	38	69	88
	June	2,358	0.15	0.5	64	256	56	394	22	78	94
	July	1,734	0.15	0.5	84	211	25	196	21	88	89
XXXIX	January	4,306	0.51		119	180	46			75	
0.29 M.G.D.	February	5,262	0.45	1.9	86	172	47	220	59	72	73
Bio-filter	March	4,482	0.48	1.7	108	175	42	207	90	76	52
	April	4,480	0.44	2.0	99	160	45	208	108	72	47
	May	6,100	0.44	2.0	72	205	46	243	90	76	62
	June	6,600	0.46	1.9	70	217	46	260	98	79	62
	July		0.53	1.5		213	55	196	86	74	56

per cent of the B.O.D. removal is accomplished in the first stage with the remaining 15 per cent in the second stage. According to the design units setup by the OCE, both plants contain the same acre feet of stone.

TABLE VI.—*Operating Results—Two Stage High Capacity Filters*

Post and Designed Capacity	Month	Contributory Pop.	Average M.G.D. Flow	Recirculation Ratio		Flow—Gal./Cap./Day	Average B.O.D.		Aver. Susp. Sol.		% Reduction	
				1st Stage	2nd Stage		Raw	Effluent	Raw	Effluent	B.O.D.	Susp. Sol.
XII	Previous											
2.24 M.G.D.	Average	26,348	1.93	1.38	1.53	68	211	28	227	27	87	89
32,000	March	26,892	1.50	2.03	1.74	56	211	31	212	31	85	89
Bio-filter	April	31,330	1.65	1.76	1.67	53	212	31	294	33	85	89
	May	31,058	1.76	1.61	1.79	57	224	28	272	30	88	89
	June	32,752	1.98	1.24	1.72	61	187	23	250	22	88	91
	July	32,541	1.91	1.35	0.75	55	214	30	262	25	86	90
XXI	Previous											
2.0 M.G.D.	Average	4,995	1.13	1.75	1.75	187	110	16	66	12	84	85
28,600	March	9,877	1.49	1.33	1.33	151	177	22	77	16	87	80
Bio-filter	April	12,620	1.58	1.27	1.27	125	263	31	84	14	88	84
	May	11,562	1.33	1.52	1.52	115	234	21	97	12	91	88
	June	11,562	0.97	2.1	2.1	84	276	18	84	12	93	85
	July	10,898	1.03	1.9	1.9	94	194	11	86	5	94	94
	August	10,058	0.94	2.1	2.1	93	218	22	98	8	90	91
XVI	Previous											
1.05 M.G.D.	Average	8,975	.75	1.11	1.94	86	242	35	281	36	86	87
15,000	March	11,728	.68	.87	2.38	58	331	59	514	85	82	83
Bio-filter	April	12,452	.69	.86	2.22	55	283	48	422	78	83	82
	August	10,685	0.69	0.70	0.96	62	306	40	411	24	87	94
XIX	Previous											
1.26 M.G.D.	Average	16,765	1.41	1.24	1.11	77	285	73	181	41	75	79
18,000	March	23,827	1.63	1.02	.96	68	284	84	180	56	70	69
Bio-filter	April	23,146	1.45	1.12	1.17	63	330	70	246	43	79	82
	May	22,464	1.50	1.01	.82	67	320	84	240	35	74	86
	June	22,846	1.528	1.33	.98	67	343	73	233	38	79	84
	July	24,305	1.614	1.73		66	378	96	218	34	75	85
XV	Previous											
1.26 M.G.D.	Average	24,514	1.09	5.10	5.34	45	297	30	284	21	90	92
18,000	March	28,372	1.31	4.28	4.28	46	296	52	270	58	82	79
Bio-filter	April	29,500	1.16	4.85	4.85	39	360	40	281	54	89	81
	May	31,785	1.22	4.60	4.60	38	363	45	262	54	88	79
	June	30,940	1.215	5.36	3.88	39	388	45	261	44	88	83
	July	29,429	1.238	5.42	3.40	42	330	52	232	45	84	80
IX	Previous											
0.84 M.G.D.	Average	7,237	.756	.46	.38	108			194	26		87
12,000	March	9,090	.896	.76	.67	99	155	9	175	15	94	91
Bio-filter	April	8,747	1.09	.78	.56	125	171	8	198	12	95	94
	May	7,477	1.13	.75	.50	151	156	12	138	15	92	89
	June		1.07	.79	.59		158	11	155	16	93	90
	July		1.05	.81	.61		166	8	186	12	95	94
XXXX	April		0.60	1.4	3.1		132	19	223	30	85	94
0.43 M.G.D.	May	7,173	0.66	1.3	2.9	92	118	19	242	13	83	95
Bio-filter	June	7,682	0.74	1.2	2.7	96	106	14	247	25	85	90
	July	10,015	0.77	1.1	2.7	77	92	11	214	24	88	90

Table VII.—*Operating Results—Activated Sludge Plants*

Post and Designed Capacity	Month	Contributory Pop.	Aver. M.G.D. Flow	Flow—Gal./Cap./Day	Average B.O.D. Raw	Average B.O.D. Effluent	Aver. Susp. Sol. Raw	Aver. Susp. Sol. Effluent	% Reduction B.O.D.	% Reduction Susp. Sol.	P.P.M. Mixed Liquor	Sludge Index	C.F. Air/Gallon	% Returned Sludge
V	Previous													
1.96 M.G.D.	Average	20,088	1.46	74	371	38	295	38	89	85	427	872		
28,000	March	15,832	1.50	95	282	14	201	12	95	94	473	711		
Mechanical	April	27,313	1.91	70	381	71	262	77	81	71	568	1,719		
	May	28,227	2.10	75	354	127	243	107	64	56	236	4,167		
	July	22,851	2.08	91	299	55	202	47	82	77	487	828		
	August	20,445	2.04	100	298	56	223	50	81	77	338	1,390		
XXIV	Previous													
4.2 M.G.D.	Average	42,396	4.87	112	179	25	208	34	87	83	1,209	402	1.22	33
Diffused Air	March	38,972	5.79	148	298	21	255	19	93	93		476	1.4	30
	April	46,259	4.45	96	424	30	464	26	93	94	1,175	523	1.6	40
	May		2.68		277	17	321	7	94	97.8	1,367	487	2.7	64
	June		2.94		281	31	173	36	89	79	1,588	338	3.0	54
	July		3.20		328	22	359	17	93	95	1,362	336	2.8	53
	August		2.94		350	22	341	17	94	95	1,309	194	3.1	54
XIII	Previous													
0.70 M.G.D.	Average	10,220	.81	63	252	41	268	62	83	77	761	578	1.8	22
10,000	March	17,000	.61	36	321	49	342	52	84	84	1,304	476	2.7	35
Diffused Air	April	18,000	1.2	67	379	80	246	76	79	69	779	315	0.8	
XXV	January	1,111	0.095	86	137	20	172	9	85	92	430	1,080		
Mech. Aerator	February	2,091	0.16	77	150	17	189	34	89	82	516	826		
	March	2,491	.17	68	132	15	131	12	89	91	384	1,026		
	April	2,710	.16	59	175	12	171	7	93	96	510	1,035		
	May	1,892	.106	56	166	11	165	11	93.5	93	491	1,436		
	June	1,496	.080	53	226	12	202	10	95	95	760	649		
	July	1,517	.071	47	235	13	189	43	94	77	320	1,661		
	August	1,737	.083	48	201	13	304	55	93	82	301	1,392		

To save critical materials, it is possible that the Army can eliminate two-stage plants and have the single-stage plant designed for dual recirculation as in Post XIV of Table V, discussed in detail in the July paper, *This Journal.*

All types of high capacity filters have shown filter fly breeding, and flooding and chlorination is being practiced extensively for control. Another disappointing feature of the high capacity filter is the discolored effluent. It is usually found with a reddish brown tinge. Unfortunately riparian owners are more impressed by a turbid effluent than they are with the analytical data.

Figure 18 has been constructed from data in an exceptionally comprehensive report by Mr. J. T. Frank covering a 6-month operating period from Post XVII where the original two-stage biofilter plant has been supplemented by a standard-rate filter. For some time the OCE

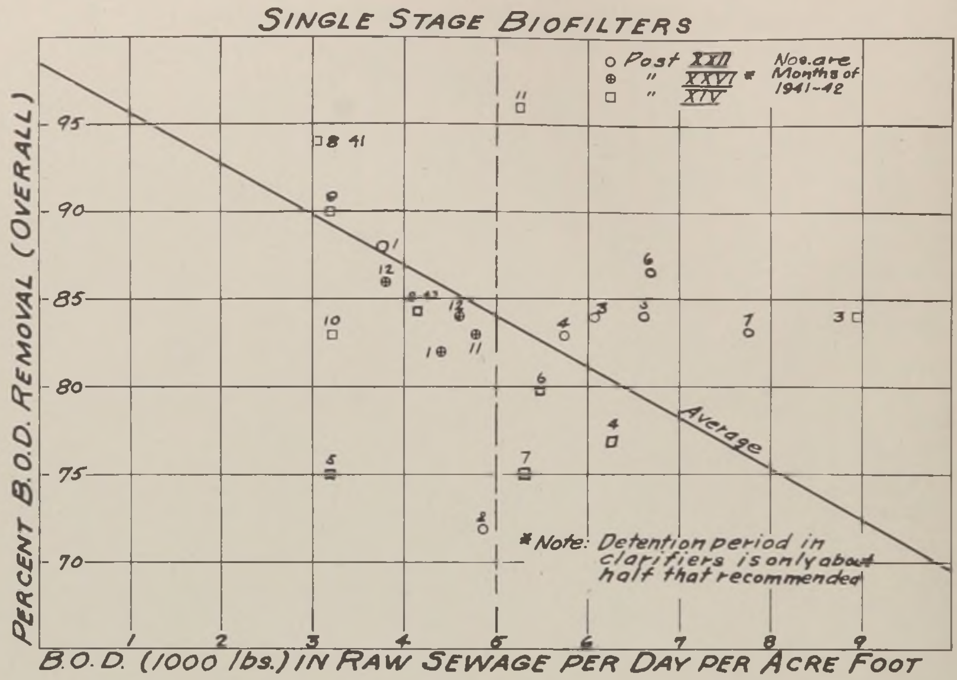

Fig. 15.

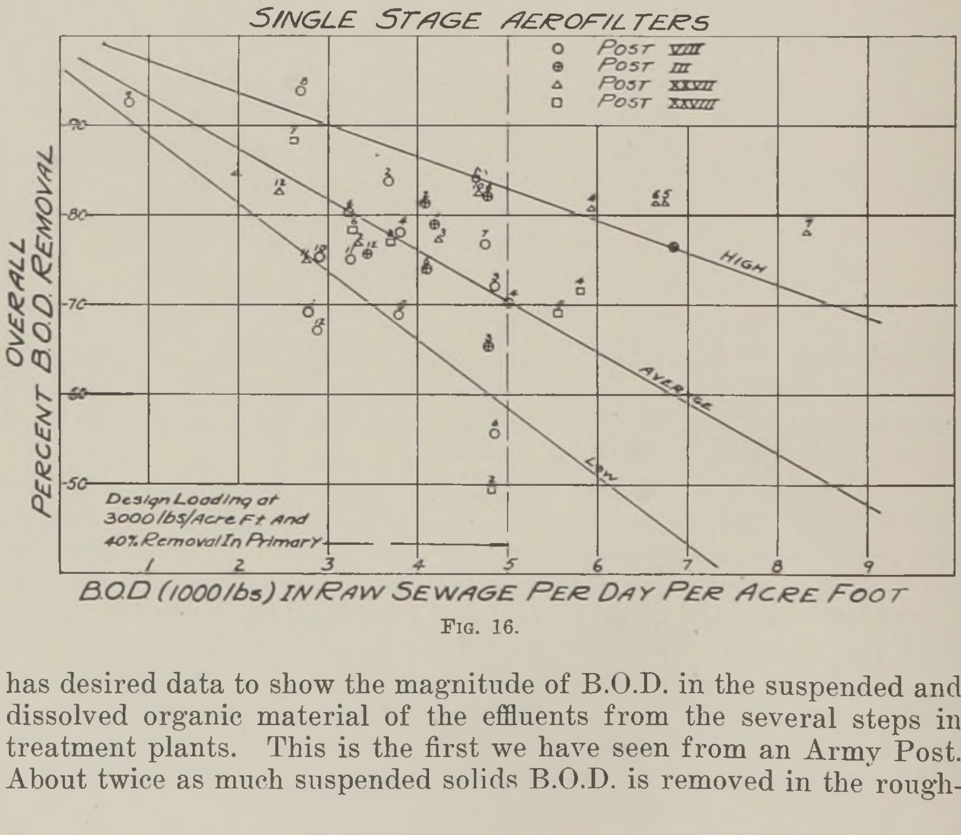

Fig. 16.

has desired data to show the magnitude of B.O.D. in the suspended and dissolved organic material of the effluents from the several steps in treatment plants. This is the first we have seen from an Army Post. About twice as much suspended solids B.O.D. is removed in the rough-

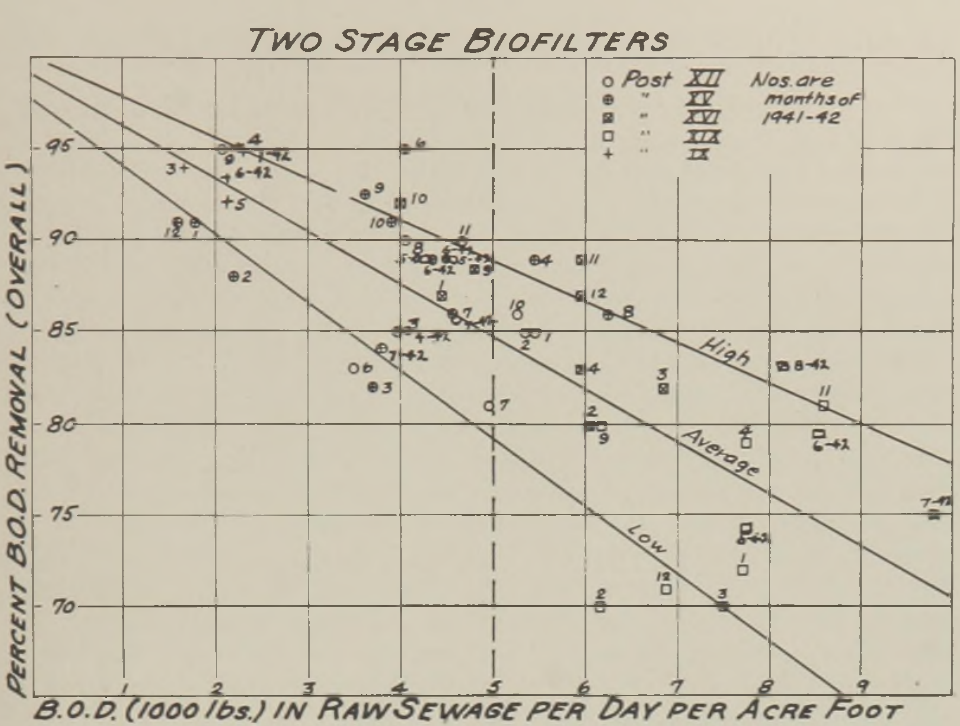
TWO STAGE BIOFILTERS
PERCENT B.O.D. REMOVAL (OVERALL)
B.O.D. (1000 lbs.) IN RAW SEWAGE PER DAY PER ACRE FOOT
o Post XII
⊕ " XV
⊠ " XVI
□ " XIX
+ " IX
Nos. are months of 1941-42
High
Average
Low

FIG. 17.

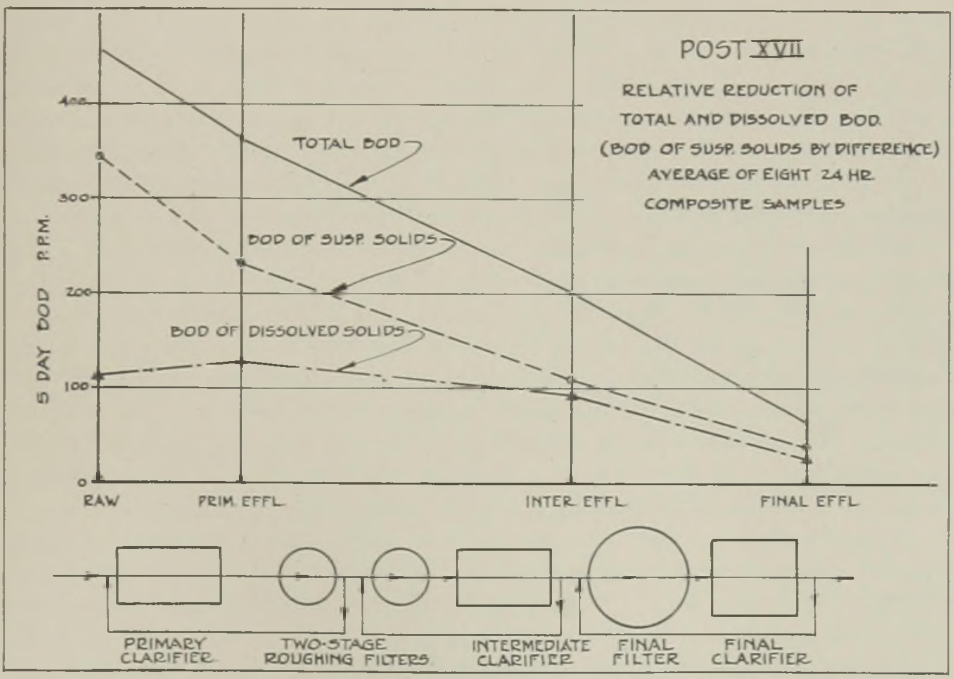
POST XVII
RELATIVE REDUCTION OF
TOTAL AND DISSOLVED BOD
(BOD OF SUSP. SOLIDS BY DIFFERENCE)
AVERAGE OF EIGHT 24 HR.
COMPOSITE SAMPLES
5 DAY BOD P.P.M.
TOTAL BOD
BOD OF SUSP. SOLIDS
BOD OF DISSOLVED SOLIDS
RAW
PRIM. EFFL.
INTER. EFFL.
FINAL EFFL.
PRIMARY CLARIFIER
TWO-STAGE ROUGHING FILTERS
INTERMEDIATE CLARIFIER
FINAL FILTER
FINAL CLARIFIER

FIG. 18.

ing stage as in the final stage, whereas the reverse is true of the dissolved solids B.O.D.

One of the difficulties in establishing design units for high capacity filters is that, because of the recirculation of the effluents, it is hard to predict the pounds of suspended solids and B.O.D. loading on the filters. Also in actual operation considerable testing and computation are required to obtain loadings. The mechanism of the treatment process in essentially non-nitrifying high capacity filters is intriguing and it was thought that complete analyses might give a clearer concept of the function of this filter, considering environmental factors only. Table VIII shows an analysis of treatment results at Post XXVI from a single-stage filter, not designed according to any one patented process. Unfortunately the filter drains are always submerged. Composite samples were analyzed every third day for three months. March, 1932, data are shown with January and February averages in Table VIII. The suspended solids and B.O.D. removed from the final tank and returned, are calculated. All other data are based on observed values. Recirculation is continuous from the bottom of the center of the final settling tank to the primary tank inlet. All solids except those in the effluent are returned. Analyses were not made on the recirculated flow, the assumption being that the total loading returned to the primary was the same as the removal in the final tank.

Using March averages and establishing a B.O.D. balance (see Fig. 19), the filter removed 1592—1046 or 546 pounds B.O.D. This is only 34.3 per cent. A study of daily results shows that the removal is as low as 17 per cent and occasionally may be as high as 45 per cent. The large reduction occurs in the settling in the final tank, which is evidenced in the March average by 1,046—239 or 807 pounds B.O.D. or 77.0 per cent removal. This result is unusually significant because it permits a review of the concept of the behavior of a high capacity filter. The filter appears to perform two functions. One is that which causes an oxidation phenomenon and the other can be likened to the work of a conditioner or colloider similar to the performance of an activated sludge unit. We would not compute an activated sludge unit efficiency by measuring the B.O.D. of the mixed liquor at the outlet end of the aeration tank, but rather at the outlet end of the final settling tank. However, for many years standard rate filters, which may possess both functions and others, were permitted to be installed in this country without final settling tanks. It took many years of poor control of stream pollution to cause the installation of final tanks and later the idea of returning effluent from the final settling tank in the case of the high capacity filter.

A study of these data by specific days will show that almost always greater amounts of suspended solids leave the filter than are found in the influent to the filter. The monthly average always shows this fact. With few exceptions even when the increase in suspended matter is of considerable magnitude, the overall reduction in B.O.D. in the filter still compares favorably with the monthly average removal B.O.D. reduc-

TABLE VIII.—*High Capacity Filter Sewage Treatment Plant, Post XXVI*

Biochemical Oxygen Demand Analysis

Date	Flow M.G.D.	Recir. Flow M.G.D.	Total Flow M.G.D.	Pop. Equiv.	5 Day Biochemical Oxygen Demand								
					Raw			Settled		Filtered		Final	
					P.P.M.	Lbs.	Lbs. Cap.	P.P.M.	Lbs.	P.P.M.	Lbs.	P.P.M.	Lbs.
Mar. 3	0.664	0.858	1.522	9,582	310	1,710	0.178	138	1,750	139	1,760	35	193
6	0.807	0.897	1.704	9,571	228	1,530	0.160	103	1,460	99	1,400	67	450
9	0.743	0.887	1.630	9,551	244	1,510	0.158	135	1,830	78	1,060	54	334
12	0.665	0.877	1.542	8,466	340	1,880	0.222	133	1,700	124	1,590	51	282
15	0.589	0.916	1.505	8,615	286	1,400	0.163	81	1,010	38	475	20	98
18	0.797	0.897	1.694	9,862	294	1,960	0.197	125	1,760	55	775	26	172
21	0.715	0.858	1.575	10,128	165	980	0.097	71	930	38	497	30	178
24	0.702	0.858	1.560	9,974	238	1,385	0.138	124	1,610	66	855	40	233
27	0.665	0.877	1.542	8,728	281	1,550	0.178	112	1,440	45	580	28	155
30	0.706	0.916	1.622	9,000	252	1,480	0.165	180	2,430	112	1,510	51	299
Average	0.705	0.884	1.589	9,347	264	1,539	0.165	120	1,592	79	1,046	40	239
Jan. Ave.	0.640	0.844	1.484	6,922	270	1,439	0.206	138	1,697	109	1,336	46	252
Feb. Ave.	0.688	0.895	1.583	8,909	304	1,730	0.193	151	1,996	101	1,322	48	258

Suspended Solids Analysis

Date	Suspended Solids								
	Raw			Settled		Filtered		Final	
	P.P.M.	Lbs.	Lbs. Cap.	P.P.M.	Lbs.	P.P.M.	Lbs.	P.P.M.	Lbs.
Mar. 3	420	2,310	0.241	142	1,800	121	1,530	56	310
6	345	2,310	0.241	129	1,830	200	2,830	33	220
9	450	2,780	0.291	140	1,900	220	2,980	40	247
12	280	1,550	0.183	120	1,540	300	3,850	46	254
15	370	1,810	0.210	132	1,650	286	3,580	41	200
18	395	2,610	0.265	140	1,970	302	4,260	40	265
21	410	2,400	0.240	138	1,810	200	2,620	48	286
24	380	2,220	0.222	140	1,810	289	3,750	42	245
27	400	2,200	0.252	128	1,640	200	2,570	30	166
30	390	2,290	0.255	132	1,780	275	3,720	38	223
Average	384	2,248	0.240	134	1,773	239	3,169	41	242
Jan. Ave.	322	1,713	0.245	172	2,134	226	2,791	44	238
Feb. Ave.	316	1,792	0.202	128	1,687	175	2,306	51	295

tion. Aerobic digestion of solid matter must be taking place on the rocks of the filter.

With this type of flow diagram, using recirculation of all final settled sludge, it appears that the correct design and operation of settling tanks

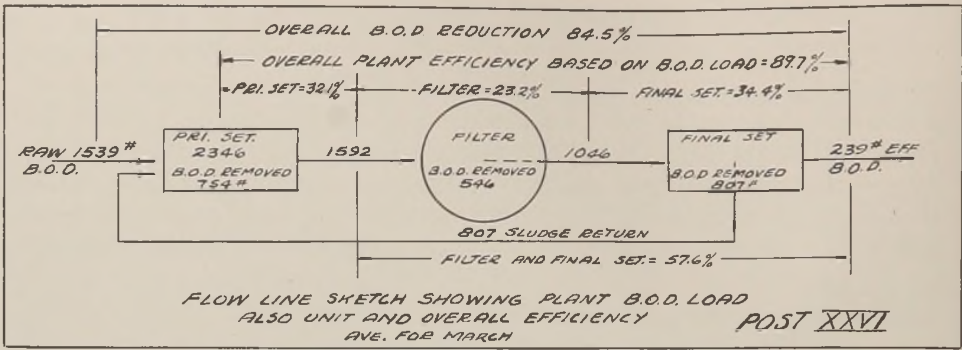

Fig. 19.

is vital because of the required quick and adequate removal of fresh filter solids.

Originally this plant was operated by discharge of most of the recirculated flow from the bottom of the final tank to the inlet of the filter rather than the inlet to the primary tank. This was believed necessary to maintain the normal detention period in the primary tank of about 3 hours in accord with the original OQMG design requirements.

The full-scale experiment was carried out by Lt. Herbert B. Foster of the Sanitary Corps, formerly of the California State Board of Health, who not only made the tests but trained inexperienced plant operators as well.

The final clarifier capacity at this plant is 2.5 hours detention for average raw sewage flow with a 735 gallon per square foot per day overflow rate. Normal design practice with effluent return from the launder, all in accord with the OCE Design Manual and recommendations of companies holding proprietary processes required the same 2.5 hr. detention period based upon the total flow including recirculation. With recirculation taken from the bottom of the tank the present detention period is about one hour and appears to be satisfactory. This is particularly interesting because of the short primary detention period of 1.3 hours now available. At the time the senior author visited the plant in May, there was evidence of very slight ponding on the filter in a few spots which was being observed closely by Lt. Foster. Subsequent reports have shown no ponding difficulties and treatment results show about 85 per cent B.O.D. overall removal. The rate of application on the filter averages 29 m.g.a.d.

If the return were designed to be collected from the effluent launder the overflow rate would be 1650 gal. per sq. ft. per day. The post had requested through channels, funds for installation of a new circular launder near the center of the tank. It is believed such an installation would be detrimental to plant operation. Indications are that the return of fresh filter solids to the primary tank is beneficial to the removal of organic material by coagulation and direct adsorption of colloidal material on the filter solids, similar to behavior of well conditioned return activated sludge.

Contact Aeration (Hays Process)

Tables IX to XIII show all the operating results we have on five plants of the Hays type. No other data are available. The data on Posts XLII and XLIII were transmitted by Dr. G. W. Cox and V. M. Ehlers of the Texas State Board of Health and tests were conducted in their laboratory trailer stationed at the plants. All other data are from sanitary and associate sanitary engineers of the War Department. Samples were 24-hour composites. In the case of Post XLI, the largest plant in operation, all test data are based on daily analyses.

In Post XXX the plant started operation in December, 1941, and the overload during the first three months was higher than that shown in Table IX. The contact period in the aeration stages is much lower than in the other plants. In all these plants the detention period is very low compared to activated sludge requirements but high compared with the contact time in high capacity filters. The original design basis was about 0.64 lb. B.O.D. per 100 sq. ft. of plate area (Table X). Plant XXX is overloaded about 72 per cent. This is due in part to limed digester supernatant from an unheated digester still in the acid stage. In June, the supernatant was by-passed and the B.O.D. overload was 14 per cent and on a population basis 6 per cent. Plans are under way to extend the plant, because a high degree of treatment is required. No dissolved oxygen has ever been maintained in the first-stage aeration, even with air supply well above 1.5 cu. ft. per gallon.

Post XLII has 0.52 lb. B.O.D. loading per 100 sq. ft., which is below the design unit by about 20 per cent but this is more or less in line with existing and design populations. The flow is 75 per cent over the design rate. It appears that if the organic load is not too high, the high flow rates are successfully treated. The detention periods in the settling tanks are less than in any of the other plants, in no case above 1.77 hours. The good results indicate that with this process perhaps shorter settling periods are desirable. The 0.67 cu. ft. of air per gallon is the lowest used in any plant but the .004 cu. ft. per square foot of plate area per minute is approximately the value reported in the other plants, and appears to be about the correct value that should be used to obtain the desired scrubbing action on the plates. It is regretted no dissolved oxygen data are available. The test data for primary removal includes return secondary sludge, supernatant, grease and scum from the primary tank which is all returned to the wet well. The high primary B.O.D. removal indicated is believed due to the failure to provide for disposal of skimmings which accumulate as they are continually recirculated.

In Post XLIII the plant is overloaded in population by 15 per cent and return supernatant is treated with lime. B.O.D. overload is 23 per cent. The air supply of 2.2 cu. ft. per gallon is higher than that used in Post XXX, but the overall suspended solids and B.O.D. removal is comparable.

At Post XLV, the plant is just starting operation. During the tests it was underloaded. At the 6,000 population figure the plant could not

Table IX.—*Hays Process—Suspended Solids Removal*

Post	XXX					XXXXII		XXXXIII		XXXXV	
Period	Design Data	April 1942	June 1942	July 1942	August 1942	Design Data	2-23 to 3-2-42	Design Data	4-15 to 5-6-42	Design Data	9-19 to 21-1942
Contributory Pop.	26,000	31,000	27,500	30,000	28,864	4,000	3,155	2,250	2,600	6,000	2,600
Flow—M.G.D.											
Average	1.82	2.46	2.40	2.39	2.28	0.28	0.49	0.157	0.158	0.420	0.161
Max. Rate	5.45	4.08	5.45	4.84	5.45	0.84	0.63	0.471	0.325	1.26	0.358
Min. Rate	0.73	1.25	1.07	1.02	0.51	0.11	0.36	0.063	0.093	0.17	0.025
Settling Period—Hrs.											
Primary	3.0	2.27	2.32	2.33	2.45	3.09	1.77	3.4	3.42	2.6	6.76
Intermediate	2.2	1.64	1.68	1.69	1.77	1.40	0.81	1.38	1.39	1.2	3.12
Final	2.2	1.64	1.68	1.69	1.77	1.87	1.07	2.41	2.42	2.4	6.24
Suspended Solids, P.P.M.											
Raw Sewage		272	294	235	219		193		158		220
Primary Clarifier Eff.		202	113	157	163		102		102		72
Inter. Clarifier Eff.							58		57		
Final Effluent		50	42	87	57		25		58		30
Per Cent Reduction											
Primary Clarifiers		26	62	33	26		47		32		67
1st Stage Aeration		75	63	45	65		43		43		58
2nd Stage Aeration	(Incl. with 1st Stage Above)						57		36		Incl. with 1st Stage
Overall Removal		82	86	63	74		87		75		86
	Supernatant Bypassed to Outfall										

TABLE X.—*Hays Process*

B.O.D. Removal

Post	XXX					XLII		XLIII		XLV	
Period	Design Data	April 1942	June 1942	July 1942	August 1942	Design Data	2-23 to 3-2-42	Design Data	4-15 to 5-6-42	Design Data	9-19 to 21-1942
Contact Period, Hrs.	1.83	1.36	1.39	1.39	1.46						
1st Stage	0.915					1.39	0.80	1.47	1.46	2.6	6.76
2nd Stage	0.915					1.25	0.72	1.32	1.31	1.8	4.68
Plate Area—Sq. Ft.											
1st Stage	233,300					30,240		15,120		44,000	
2nd Stage	193,740					27,216		13,600		36,000	
Air Supply											
Cu. Ft. per Gal.	1.52		1.38	1.70	1.82	1.16	0.67	1.12	2.22	1.67	4.34
Cu. Ft. per Sq. Ft. per Min.	0.0045		0.0055	0.0066	0.0067	0.004	0.004	0.004	0.0085	0.006	0.006
B.O.D., P.P.M.											
Raw Sewage		233	251	239	295		159		205		300
Primary Clarifier Effluent		221	156	230	258		73		173		267
Inter. Clarifier Effluent		130					35		96		182
Plant Effluent		67	55	96	94		18		68		110
B.O.D. Loading, Lbs.											
Raw Sewage		4,780	5,030	4,760	5,600		649		270		402
1st Stage Aerator		4,530	3,120	4,580	4,900		297		228		358
Per 100 Sq. Ft. Contact Surface		1.95	0.73	1.07	1.15		0.98		1.51		0.81
2nd Stage Aerator		2,670	(Both Stages Incl. Above)				142		126		245
Per 100 Sq. Ft. Contact Surface		1.38	(Both Stages Incl. Above)				0.52		0.93		0.68
Plant Effluent		1,370	1,100	1,910	1,790		72		90		148
B.O.D. Reduction, Per Cent											
Primary Clarifier		5	38	4	12		54		16		11
1st Stage Aeration		41	65	58	64		52		45		32
2nd Stage Aeration		49	(Both Stages Incl. Above)				49		29		40
Overall Removal		71	78	60	68		89		67		63
D.O., P.P.M.											
1st Stage Aeration				0.0	0.0						0.0
2nd Stage Aeration				1.4	1.0						0.0
Plant Effluent		0.3	0.7	1.7	0.7						0.0

TABLE XI.—*Hays Process, Post XLI, Design and Operating Conditions*

	Design Data	8-20-42 to 8-31-42	9-1-42 to 9-7-42	9-8-42 to 9-15-42	9-16-42 to 9-23-42	9-24-42 to 9-30-42	10-1-42 to 10-8-42
Population (Contributory)	35,000	26,000	26,000	28,000	20,000	20,600	20,000
Sewage Flows—M.G.D.							
Average	2.45	1.80	1.50	1.40	1.00	1.00	1.10
Maximum	7.35	3.50	3.30				
Minimum	0.98	0.40	0.40				
Settling Period—Hrs.							
Primary	3.20	1.68	3.40	3.70	5.20	5.20	4.70
Intermediate	1.44	1.07	1.20	1.20	1.70	2.30	3.20
Final	2.60	1.54	2.20	2.30	3.20	3.20	2.90
Contact Period—Hrs.							
1st Stage	1.90	2.38	3.10	3.30	4.70	4.70	4.30
2nd Stage	1.40	1.37	2.30	2.50	3.50	3.50	3.20
Air Supply							
Cu. Ft. per Gal.	1.172	2.38	2.90	3.00	4.20	4.20	3.80
Cu. Ft. per Sq. Ft. per Min.	0.0036	.0055	.0055	.0053	.0053	.0053	.0053
Volume Supernatant, Gal. per Day		25,786	11,820	13,400	7,900	8,470	

Surface Area of Plates: 1st Stage—312,000 Sq. Ft.; 2nd Stage—237,280 Sq. Ft.

TABLE XII.—*Hays Process, Post XLI, Suspended Solids Analyses*

Period	8-20-42 to 8-31-42	9-1-42 to 9-7-42	9-8-42 to 9-15-42	9-16-42 to 9-23-42	9-24-42 to 9-30-42	10-1-42 to 10-8-42
Suspended Solids, P.P.M.						
Raw Sewage	219	237	275	258	316	261
Primary Clarifier Effluent	111	117	123	105	133	116
Intermediate Clarifier Effluent	67	91	93	73	81	59
Plant Effluent	53	72	68	19	57	8
Suspended Solids, Loading, Lbs.						
Raw Sewage	3280	2964	3210	2150	2635	2395
1st Stage Aeration	1660	1464	1432	875	1108	1065
2nd Stage Aeration	1000	1137	1085	609	675	541
Plant Effluent	790	900	793	158	475	73
Suspended Solids Removal, Per Cent						
Primary Clarifiers	50	51	55	59	58	55
1st Stage Aeration	40	22	24	30	39*	49
2nd Stage Aeration	21	21	27	74	30*	87
Overall Removal	76	70	75	93	82	98

* Air Increased in 1st Stage, Decreased in 2nd Stage.

be successfully operated. The population is now 12,000 but no decision has been arrived at as to alterations.

The operators at Post XLI were very conscientious in obtaining the observed results and getting them to us week by week. The table is arranged to show the improvement in operation and is the only good study we have with complete daily control tests. Digester supernatant is conditioned with lime but no laundry waste was treated during these periods. Sludges from all settling tanks are discharged to condition-

Table XIII.—*Hays Process, Post XLI, B.O.D. Analyses*

Period	8-20-42 to 8-31-42	9-1-42 to 9-7-42	9-8-42 to 9-15-42	9-16-42 to 9-23-42	9-24-42 to 9-30-42	10-1-42 to 10-7-42
B.O.D.—P.P.M.						
Raw Sewage	278	281	346	323	390	434
Primary Clarifier Effluent	191	182	213	207	234	239
Intermediate Clarifier Effluent	160	130	135	122	72	80
Plant Effluent	101	65	58	25	31	22
B.O.D. Loading, Lbs.						
Raw Sewage	4160	3440	4040	2690	3250	3980
1st Stage Aeration	2840	2230	2490	1730	1950	2200
Per 100 Sq. Ft. Contact Surface	.91	1.10	0.80	0.55	0.62	0.70
2nd Stage Aeration	2390	1590	1580	1020	600	730
Per 100 Sq. Ft. Contact Surface	1.01	.67	0.66	0.43	0.25	0.31
Plant Effluent	1480	794	680	210	260	200
B.O.D. Reduction, Per Cent						
Primary Clarifier	32	35	38	36	40	45
1st Stage Aeration	16	29	37	41	69	67
2nd Stage Aeration	38	50	57	80	57	72
Overall Removal	64	77	83	92	92	95
Dissolved Oxygen, P.P.M.						
1st Stage Aeration	0.0	0.0	0.0	0.0	3.0*	3.2
2nd Stage Aeration	0.2	3.2	2.1	4.7	3.1*	3.2
Plant Effluent	0.0	0.0	0.6	1.9	1.9	2.1
B.O.D.—Supernatant		1800		1800	964	

* Air Increased to 1st Stage, Decreased to 2nd Stage.

ing tanks and then directly to the digesters, rather than return to the primary.

It was difficult to obtain D. O. in the first-stage aeration until the period starting September 24, when air was increased to the first stage by decreasing the air in the second stage. The immediate increase in removal of B.O.D. in the first-stage aeration is very pronounced, from 41 per cent to 69 per cent. The lower reduction in suspended solids appeared to be due to the sloughing from the plates in the first stage caused by the increased air. At first about 70,000 gallons per day of sludge was pumped to the digesters but this has been reduced to about 8,000 gallons. The best method for routine operation has not been found but pumping of sludge occurs at about 4-hour intervals. The red colored organisms in the first stage have disappeared and the greenish-brown mat is developing on the plates. The operators at this post are well qualified and Howard M. Malloy, the Sanitary Engineer in charge, has had five years of activated sludge experience at Ann Arbor, Michigan.

Operating results transmitted October 23, 1942, orally by telephone show that after discovery and repair of a large leak in one inverted siphon on October 13, the average sewage flow into the plant increased to 1.7 m.g.d. At the time of morning peak flows, the flow rate increases from about 0.3 to 5.3 m.g.d. in 20 minutes. Upon collection of the total flow, plant B.O.D. efficiency dropped to 80 per cent. On October 16, composite B.O.D. tests gave a removal of 91 per cent B.O.D. and 98 per cent suspended solids removal.

Treatment problems in general on the Hays type of plant show that high grade men will be required.

Observations to date indicate that the smaller plants have good possibilities of producing results equal to high-grade intermediate type of treatment. Based on observations without laboratory control, about eleven of the smaller plants are not producing satisfactory results. It is believed the disappointing results are due to one or all of the following:

1. Unbalanced or poor design.
2. Mechanical difficulties.
3. Inexperience of the operators and lack of control equipment.

It is contemplated to correct the latter item by holding short courses on Hays Process problems. Many of the operators have recently had some schooling in basic laboratory procedures and general plant operations.

It is hoped the larger plants will continue to show results expected of the process and indications are that, barring periodic mechanical failures, satisfactory results may materialize. It appears that more air will be required by the process than originally planned, that the designs can be improved and perhaps some mechanical features can be eliminated. In the second largest Hays Process plant, Post XLI, the total design detention period is about 10½ hours whereas with one exception, the detention period of the Army activated sludge plants is about 9½ hours. Whether the original cost and cost of operation justifies continued adoption of the process in lieu of others giving comparable results remains to be determined. It is impossible to obtain cost figures for comparison at this time.

Summary

The results disclosed in this paper cover the variety of plants now in operation by the Army under various climatic and seasonal conditions, and it is believed they are representative as to what can be expected under Army conditions which are far from stable. Generally speaking, the design and operation is in accord with the original plan to provide sewage treatment for temporary populations. Due to construction practices and requirements the major structures are in general as well built as those of municipalities and with normal maintenance and repair will provide consistent performance for the duration of the emergency. If a continuity of personnel can be maintained, we are confident the operating results will improve. Ultimately it is expected that Army plant experience will prove of value to engineers for the future design of municipal plants as well as providing a training ground for plant operators.

Operating experience so far has not shown that it is desirable for the Army to standardize on any one type of plant. We are recom-

mending that future planning and construction of contact aeration plants by the Army be deferred until successful operating methods can be evolved with subsequent determination of correct design units.

Discussion

By Guy E. Griffin

Captain, Corps of Engineers; Chief, Sanitary Section, Real Estate Repairs and Utilities Division, First Service Command, S.O.S.

These remarks will be confined to the operation of Army sewage treatment plants in New England. It might perhaps be said, somewhat facetiously, that the two largest plants in New England do a perfect job of sewage treatment and disposal in that there is no final measurable effluent to any visible stream or body of water. This is due to the fact that the final treatment units at each plant are filter beds of natural sand deposits with no underdrains.

Mention has been made in the paper of the reduction of sewage flows by the installation of flushometer valves to eliminate continuous flow through perforated pipes to urinals. It was estimated that these continuous flow devices might account for a large percentage of the high water consumptions. From July, 1941, to July, 1942, the water consumption at one Post was reduced from 108 to 60 g.c.d. and at another Post from 103 to 70 g.c.d. At the first Post the population increased somewhat but at the second it decreased. It was during this period that the flushometer installation program was largely completed although other water conservation measures were being carried out. Figure I indicates water consumption trends for two Posts and a consolidation for sixteen Posts.

At one plant the original construction provided an aerated grease skimming tank. Table I gives a summary of quantities of material skimmed from this tank from January through September 1942. These figures are somewhat a measure of the effectiveness of the individual grease trap replacement program which got well under way at this plant in May and during which month the quantity of skimmings removed at the plant fell from 19.8 to 1.3 cu. ft./m.g. The personnel problem enters strongly into the procedure of grease removal by traps in individual mess halls. To be most effective the traps should be cleaned regularly at fairly frequent intervals. In some cases this has not been done. The necessity for better supervision of this work is indicated.

In spite of the sewerage system having been designed as a separate system the amount of grit reaching one plant caused concern about the possibility of undue wear on the pump impellers of a new pumping station. The design and construction of a single channel grit chamber, cut into the gravity line ahead of the pumping station, solved this problem.

The paper has mentioned that all the plants in New England have Imhoff tanks and that in the case of one plant the Imhoff tank effluent apparently had an adverse effect on the single stage high capacity filter.

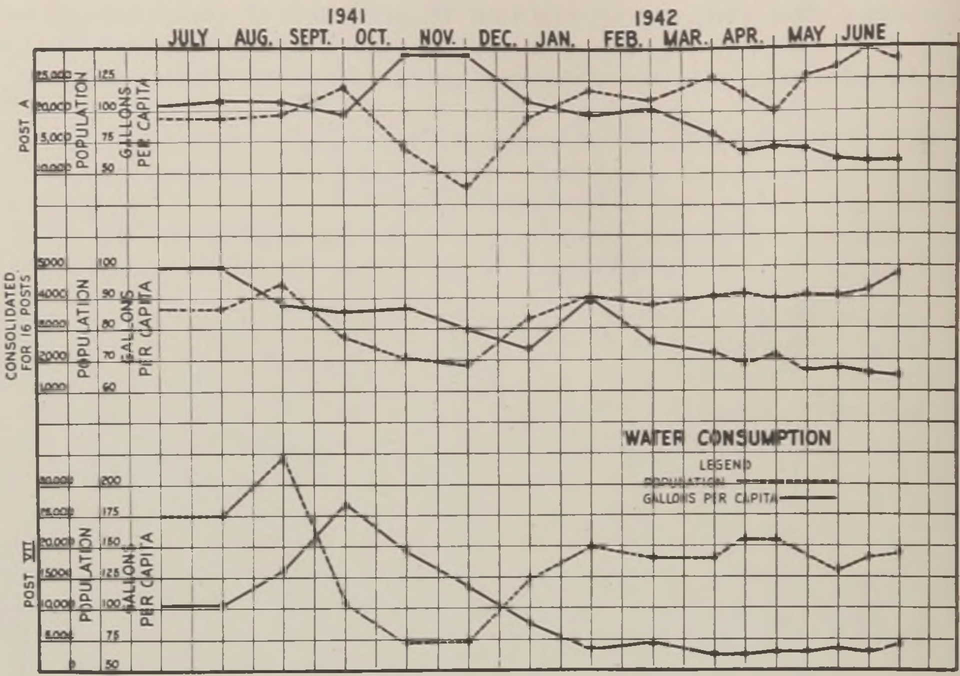

FIG. 20.

TABLE I.—*Removal by Skimming Tank, Cu.Ft./M.G.*

Post VII

Month	Quantity	Month	Quantity
1942			
Jan.	11.4	June	1.0
Feb.	14.3	July	1.5
March	19.1	August	1.1
April	19.8	Sept.	1.6
May	1.3		

Most of those Imhoff tanks were started in the winter and at the plant referred to, seeding sludge had to be carted from a considerable distance and so only a relatively small quantity was used. Larger quantities of seeding sludge were added to the Imhoff tanks of all the other plants except one where none was available. Lime was used in an attempt to control the pH of the sludge at all the plants except one.

Even with liming, however, considerable difficulty has been experienced with heavy scum accumulations in gas vents and some exchange of liquor and solids through the slots. The escape of these solids and liquor in the tank effluent has put an additional solids and B.O.D. load on the single-stage high capacity filter at Post VII making the actual applied load at times considerably more than indicated by the strength of the raw sewage.

A decided improvement in the over-all efficiency of this plant was accomplished in May, 1942, due in part to improved digestion in the Imhoff tanks but largely to the installation of shallow baffles only a few inches away from the effluent weirs. These baffles effectively hold back the floating material. During May the over-all removals were 94.5 per cent for suspended solids and 90 per cent for B.O.D.

Filter flies have not been a serious problem about the high capacity filters in New England. Many appear to breed, and reach the larva stage before they are washed out but only a few have reached the adult or flying stage.

Digested sludge has now been drawn from most of the Imhoff tanks. The sludge in most cases has been below pH 7 but has been unusually free from objectionable odors.

Possible reasons for low pH are:

a, Low alkalinity of raw sewage,

b, High grease content and, therefore, high in acid forming material. Control with lime has to be continuous to maintain pH above 7.0.

STORM WATER OVERFLOWS *

By Robert B. Stegmaier, Jr.

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Introduction

This article is a brief presentation and analysis of data obtained at the discharge end of a combined sewer. Its purpose is to aid in the solution of the problem of how much storm runoff should be discharged directly into the nearest watercourse. At present the trend in the United States and Great Britain is to give full or partial treatment to more of the overflow than has been the practice in the past.

Past and Present Practice

In England, the Ministry of Health "Requirements" for storm water overflows from combined sewers are based on dilution requirements. These have remained practically unchanged since the Fifth Report of the Royal Commission on Sewage Disposal "Methods of Treating and Disposing of Sewage—Report 1908." Briefly, these requirements state that three times the normal dry weather flow shall be given complete treatment, and that stand-by or storm water tanks shall be provided with a capacity of one-quarter of the mean daily dry weather flow. Due to the replacement of pervious surfaces with impervious roads, walks, and buildings, larger population centers, and industrial wastes, British engineers have increased the amount of the storm water flow that is given full and/or partial treatment.

In Germany, "detention basins" similar to those in England have been used since the late 1890's, not at the treatment plants as in England, but in or along the sewers in order to reduce the size of the sewers. The basins decrease the peak flows so that more complete treatment can be effected at the sewage plants.

American engineers usually provide some type of treatment for from two to four times the dry weather flow, with recent installations tending toward the higher ratios. Storm water tanks are in service at Columbus, Ohio and North Toronto, Ontario, Canada. The multiple of dry weather flow treated in North America is lower than that used in England because of the higher water consumption, which produces a more dilute sewage.

Drainage Area Characteristics

The drainage area (Fig. 1) selected for the study is one of a few isolated districts of the City of Baltimore served by combined sewers. These were built before annexation by the City. The main sewer serving the area drains 177.12 acres. When the area was developed very

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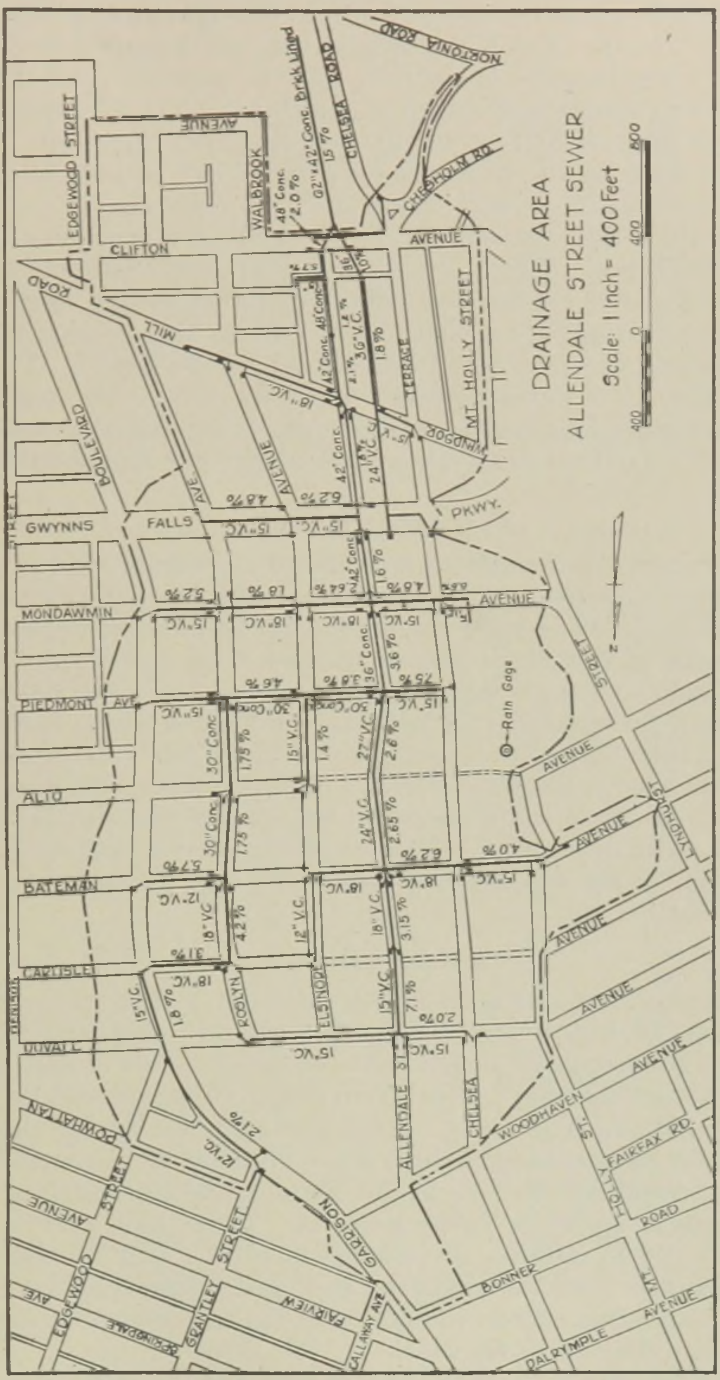

DRAINAGE AREA
ALLENDALE STREET SEWER
Scale: 1 Inch = 400 Feet
Rain Gage

FIG. 1.

little filling and grading was done except in the western portion along Chelsea Terrace where the streets were cut through, leaving steep slopes along the lot fronts. The high point is at the northern end near Bonner Road where the elevation is 420 feet. At the lower or southern end at Clifton Avenue the ground elevation is 280 feet. The average slope between these points is 3.0 feet per 100 feet or 3.0 per cent. Near the rim and within some of the drainage area the slopes are steeper, as the grades of some of the sewers shown in Fig. 1 indicate.

Nearly all of the area was developed by the construction of private detached dwellings. There are several four-story apartment houses and a few blocks of row houses. Many of the older and larger homes have been converted into apartments. Part of the western boundary of the area and some scattered lots are still undeveloped. The alleys shown in Fig. 1 are paved. Nearly every dwelling is accompanied by a garage. Approximately thirty per cent of the drainage area is impervious. The soil varies from a heavy red clay to a light gravelly loam.

Collection of Data

Measurements were made of the rainfall and runoff, and samples of the flow were collected. The quantities of flow were determined by a crude method but the results are satisfactory for a qualitative discussion. Depths of flow at the exit of the two 48-in. cast-iron pipes were recorded and from them the quantities of flow were calculated. The calculation of the quantities of flow was complicated by the fact that the 48-in. pipes were only 24 ft. long and received the flow from a small stilling chamber after it had passed over a bluff in a 36-in. cast-iron pipe on a 51.9 per cent slope. The measurement of flow was further complicated by a 24-in. interceptor. The samples were collected by holding a one-quart jar at the mid-depth of flow as close to the outlet as the discharge would permit.

Solids Data

The average dry weather flow was 0.6 cu. ft. per second. Six samples had the following average composition: total solids 289 p.p.m.; loss on ignition 204 p.p.m., or 71 per cent; and fixed solids 85 p.p.m., or 29 per cent. The total solids varied from 216 to 346 p.p.m. and the loss on ignition from 68 to 76 per cent. Data were obtained during six storms, with peak discharges ranging from 3.3 to 101.5 cu. ft. per second. The discharges, results of analyses of the samples, and rainfall data for two of the storms are given in Tables I and II. These data, with the exception of the loss on ignition, are plotted in Figs. 2 and 3. The loss on ignition, together with the discharge and fixed solids, is shown by Figs. 4 and 5. Care must be taken to note that the time and other scales are not the same in all of the figures.

The rain on the afternoon of August 15th was the smallest for which samples were collected. This shower lasted five minutes and 0.07 in. of rain fell. This was a rate of 0.84 in. per hour. The maximum rate of flow, 3.3. cu. ft. per second, was 5.5 times the average dry weather flow.

TABLE I.—*Data for Storm of August 15, 1941 (Afternoon)*

Time (P.M.)	Discharge (C.F.S.)	Turbidity (P.P.M.)	Total Solids (P.P.M.)	Fixed Solids (P.P.M.)	Loss on Ignition	
					P.P.M.	Per Cent
1:36	0.3	500	616	299	317	51.5
1:39	1.0	1100	1334	562	772	57.9
1:40	3.3	1500	2509	1176	1333	53.1
1:43	2.5	950	1318	721	597	45.3
1:46	1.8	600	1073	598	475	44.3
1:49	1.0	475	816	467	349	42.8
1:55	0.7	350	586	392	194	33.1
2:00	0.3	275	396	292	104	26.3

Rainfall in Inches

1:25–1:30 0.07 inch

Last previous rainfall: 0.44 in. in 3 hours and 40 minutes on August 12, 1941; 0.15 in. of total in 5 minutes.

TABLE II.—*Data for Storm of August 15, 1941 (Evening)*

Time (P.M.)	Discharge (C.F.S.)	Turbidity (P.P.M.)	Total Solids (P.P.M.)	Fixed Solids (P.P.M.)	Loss on Ignition	
					P.P.M.	Per Cent
6:29	0.3	200	375	207	168	44.8
6:42½	2.5	375	602	330	272	45.2
6:45	3.3	350	563	277	286	50.9
6:50	3.3	250	428	250	192	44.9
6:55	2.5	225	397	181	178	44.9
7:00	2.5	175	277	145	132	47.7
7:05	5.5	250	378	294	84	22.2
7:10	46.5	500	1084	962	122	11.3
7:15	84.5	700	1557	1374	183	11.8
7:20	27.5	550	868	780	88	10.1
7:25	14.0	425	601	520	81	13.5
7:35	5.5	275	329	251	78	23.7
7:45	2.5	200	221	168	53	24.0
8:00	0.7	200	161	108	53	32.9
8:15	1.8	150	157	100	57	36.3
8:30	0.7	150	146	84	62	42.5
8:45	0.3	150	128	67	61	47.7

Rainfall in Inches

6:25–6:30	0.02	7:00–7:05	0.14
6:30–6:35	0.02	7:05–7:10	0.11
6:35–6:40	0.01	7:10–7:15	0.01
6:40–6:45	0.01	7:15–7:20	0.03
6:45–6:50	0.01	7:20–7:25	0.01
6:50–6:55	0.02	7:25–8:15	0.10
6:55–7:00	0.04	(0.01 inch per 5 min. from 7:25 to 8:15)	

Total—0.52 in. in 1 hour and 55 minutes

Last previous rainfall: 0.07 in. in 5 minutes on the afternoon of August 15, 1941.

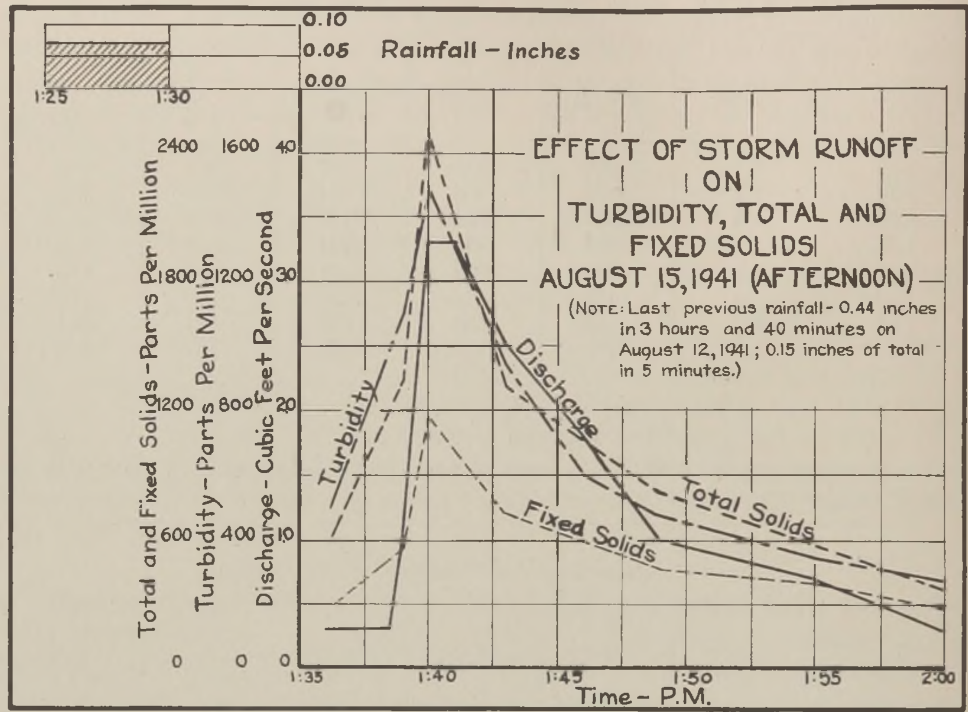

EFFECT OF STORM RUNOFF
ON
TURBIDITY, TOTAL AND
FIXED SOLIDS
AUGUST 15, 1941 (AFTERNOON)
(NOTE: Last previous rainfall - 0.44 inches in 3 hours and 40 minutes on August 12, 1941; 0.15 inches of total in 5 minutes.)
Rainfall - Inches
0.10
0.05
0.00
1:25
1:30
Total and Fixed Solids - Parts Per Million
Turbidity - Parts Per Million
Discharge - Cubic Feet Per Second
2400
1600
40
1800
1200
30
1200
800
20
600
400
10
0
0
0
Turbidity
Discharge
Total Solids
Fixed Solids
1:35
1:40
1:45
1:50
1:55
2:00
Time - P.M.

FIG. 2.

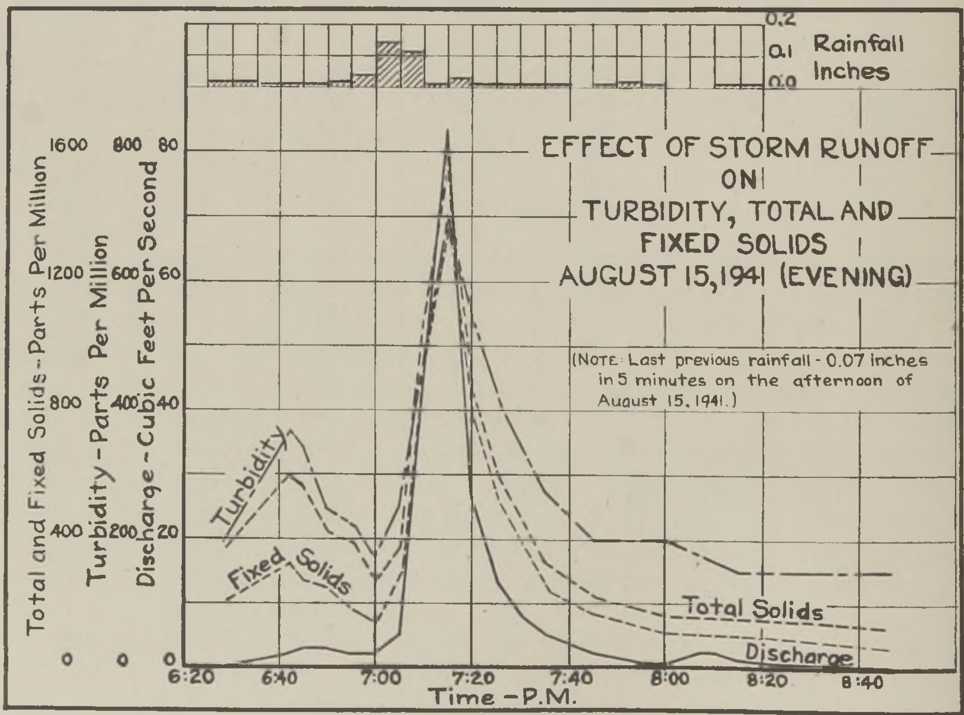
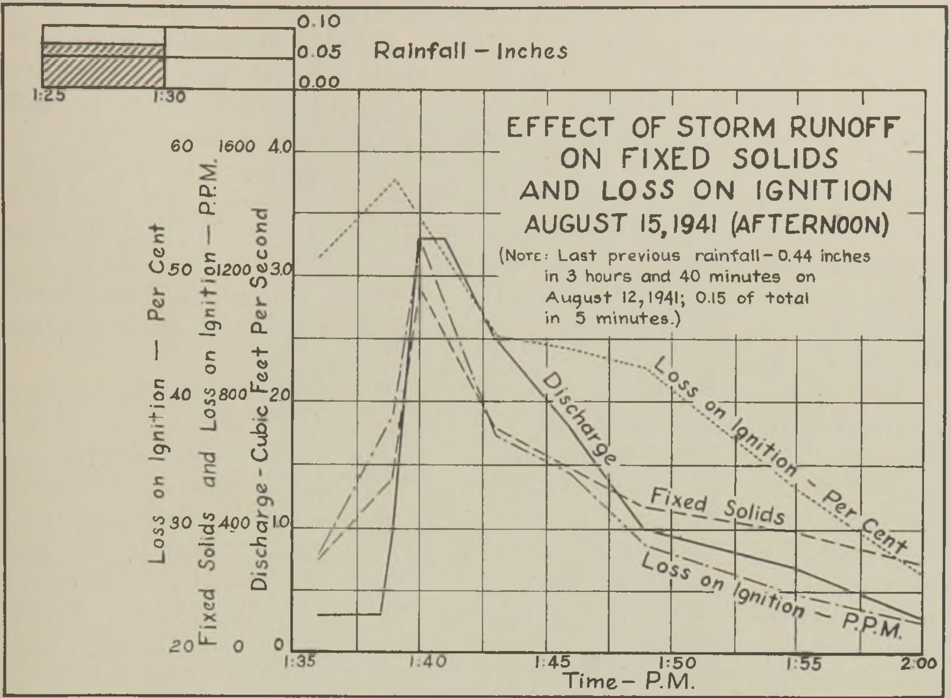
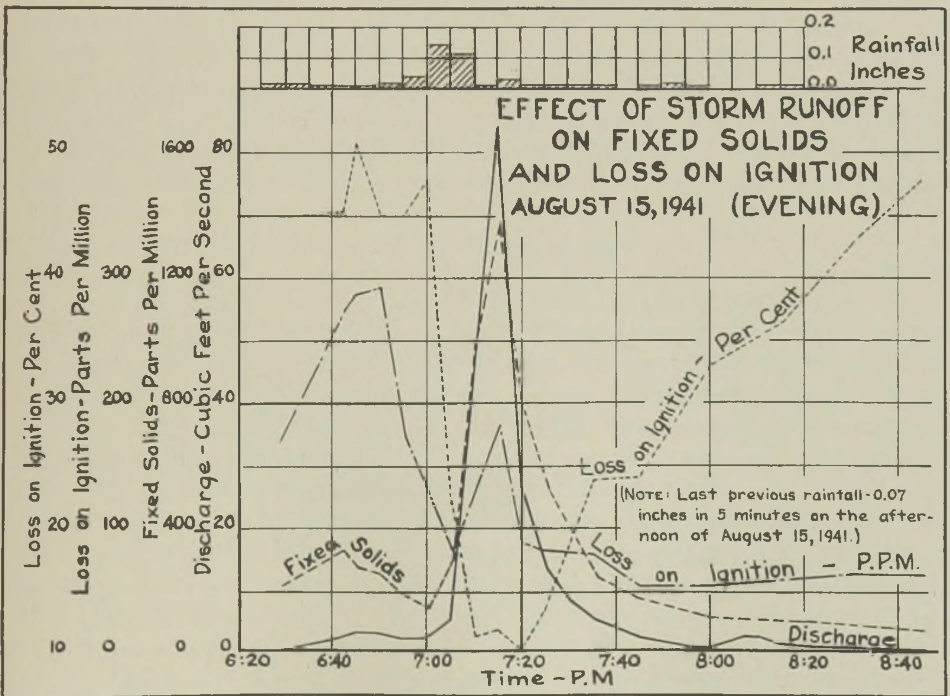

0.2
0.1
0.0
Rainfall
Inches
EFFECT OF STORM RUNOFF
ON
TURBIDITY, TOTAL AND
FIXED SOLIDS
AUGUST 15, 1941 (EVENING)
(NOTE: Last previous rainfall - 0.07 inches in 5 minutes on the afternoon of August 15, 1941.)
Total and Fixed Solids - Parts Per Million
Turbidity - Parts Per Million
Discharge - Cubic Feet Per Second
1600
800
80
1200
600
60
800
400
40
400
200
20
0
0
0
Turbidity
Fixed Solids
Total Solids
Discharge
6:20
6:40
7:00
7:20
7:40
8:00
8:20
8:40
Time - P.M.

FIG. 3.



0.10
0.05 Rainfall – Inches
0.00
1:25
1:30
EFFECT OF STORM RUNOFF ON FIXED SOLIDS AND LOSS ON IGNITION AUGUST 15, 1941 (AFTERNOON)
(Note: Last previous rainfall – 0.44 inches in 3 hours and 40 minutes on August 12, 1941; 0.15 of total in 5 minutes.)
Loss on Ignition — Per Cent
Fixed Solids and Loss on Ignition — P.P.M.
Discharge - Cubic Feet Per Second
60 1600 4.0
50 1200 3.0
40 800 2.0
30 400 1.0
20 0 0
Discharge
Loss on Ignition - Per Cent
Fixed Solids
Loss on Ignition – P.P.M.
1:35
1:40
1:45
1:50
1:55
2:00
Time – P.M.

FIG. 4.



0.2
0.1 Rainfall
0.0 Inches
EFFECT OF STORM RUNOFF ON FIXED SOLIDS AND LOSS ON IGNITION AUGUST 15, 1941 (EVENING)
Loss on Ignition - Per Cent
Loss on Ignition - Parts Per Million
Fixed Solids - Parts Per Million
Discharge - Cubic Feet Per Second
50 1600 80
40 300 1200 60
30 200 800 40
20 100 400 20
10 0 0 0
Loss on Ignition - Per Cent
(Note: Last previous rainfall - 0.07 inches in 5 minutes on the afternoon of August 15, 1941.)
Fixed Solids
Loss on Ignition – P.P.M.
Discharge
6:20
6:40
7:00
7:20
7:40
8:00
8:20
8:40
Time – P.M

FIG. 5.

The discharge during the runoff from this shower was the most polluted collected during the period of the tests. Besides the large amounts of volatile solids, the fact that the peak amounts of total, fixed, and volatile solids occurred with the peak discharge should be noted. During peak flow the amount of total solids was 8.7 times the average during dry-weather flow. The fixed solids were 13.8 times greater and the volatile solids 6.5 times greater than the dry-weather average. The last previous rain had occurred about two and one-half days earlier. During the evening storm the maximum rate of flow, 84.5 cu. ft. per second, was 141 times the average dry-weather flow. At the maximum rate of discharge the total solids were 5.4 and the fixed solids 16.2 times greater than the dry-weather average.

The major difference in the data obtained during these two storms occurred in the losses on ignition. For the evening storm, loss on ignition decreased as the flow increased, indicating an early scouring action. The loss on ignition decreased during the afternoon storm. Similar data for the other storms varied too much to permit any definite conclusion. To show more clearly the relation between the discharge and the solids, the data for the total and fixed solids were converted to rates of dry solids discharged in pounds per minute. When considered in these units the relation of the solids to the discharge was so constant that the curves were nearly interchangeable. The data indicate that the amount of solids carried by the flow was proportional to the discharge and that the first flush through the sewer did not scour out or reduce the solids during the peak flow. Examination of the total and fixed solids data shows that in practically every case the maximum difference in their values occurred during the peak discharge. That is, the maximum amount of volatile solids, as well as fixed solids, is carried by the flow during the peak discharge. Even on a unit basis the sewage contained more solids during storms, but the rate of discharge of the solids in pounds per minute dwarfs the average for dry-weather flow.

Filtration Residues

A visual record of the turbidities was made by filtering 25 ml. of each sample. To provide a standard method that would make a comparison of the filter papers possible the following procedure was followed: most of the 25 ml. sample was allowed to filter, then the heavier solids were poured into the filter cup, the contents of the filter cup were stirred by a stream of water, and the cup nearly filled; filtration followed until the paper was damp. The solids on the filter papers were not treated or fixed in any way but merely allowed to dry. By trial and error a 25 ml. sample was found to provide the most satisfactory variation in the density of the solids on the filter papers. A photograph of the mounted filter papers for the storm of the evening of August 15th, labeled with the time each sample was collected, is shown in Fig. 6. The shades and extent of the residues follow closely the values of the turbidities and amounts of solids in the samples. The colors of the deposits on the filter discs which varied from a gray-green, sometimes nearly black, to a red-brown, showed clearly the variation in their composition.

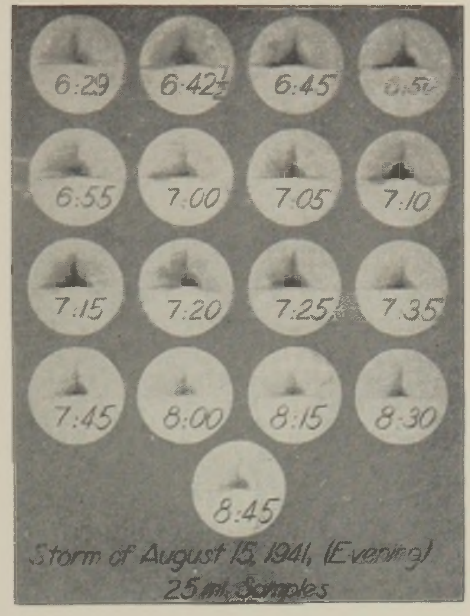


FIG. 6.—Filtration residues—storm of August 15, 1941 (evening).

HYDROLOGY

Rainfall and runoff data for six storms are not sufficient for a hydrologic study of a drainage area. The runoff data for the six storms are sufficient to show the consistent rapidity, regardless of previous rainfall, with which the discharge reached its maximum during each storm. For the six storms the peak rate of runoff at the entrance to the outfall just below Clifton Avenue occurred about twelve to fifteen minutes after the maximum rate of rainfall. Practically all of the surface runoff reached the outfall thirty minutes after the rain had fallen. Such a rapid rate of runoff resulted in flow hydrographs with sharp peaks and correspondingly high rates of discharge. The hydrographs also show that the inlet times varied from seven to ten minutes. The short inlet times are not unusual but the concentration time of twelve to fifteen minutes is unusual for a drainage area of 177 acres. The area was estimated to be 30 per cent impervious and approximately 4,600 ft. long with an average slope of 3.0 per cent.

A distribution graph was derived from the smallest storm of the series. A table of the values is given in Table III and the graph itself in Fig. 7. The short inlet and concentration times should be noted. Using the hydrograph principle this distribution graph was applied to the largest of the six storms. Its peak discharge was thirty times that of the storm from which the distribution graph was derived, but the time relationship of the several peaks of the actual hydrograph and the

TABLE III.—*Distribution Graph of Runoff from Allendale Street Sewer*

Time (In Minutes from Beginning of Five Minute Rainfall)	Discharge (Per Cent of Total Runoff for Each One Minute Period)
13	0.0
14	4.4
15	9.1
16	10.7
17	9.7
18	8.5
19	7.7
20	6.8
21	6.1
22	5.4
23	4.5
24	3.7
25	3.2
26	3.0
27	2.9
28	2.7
29	2.5
30	2.3
31	2.1
32	1.8
33	1.6
34	1.4
	Total = 100.0

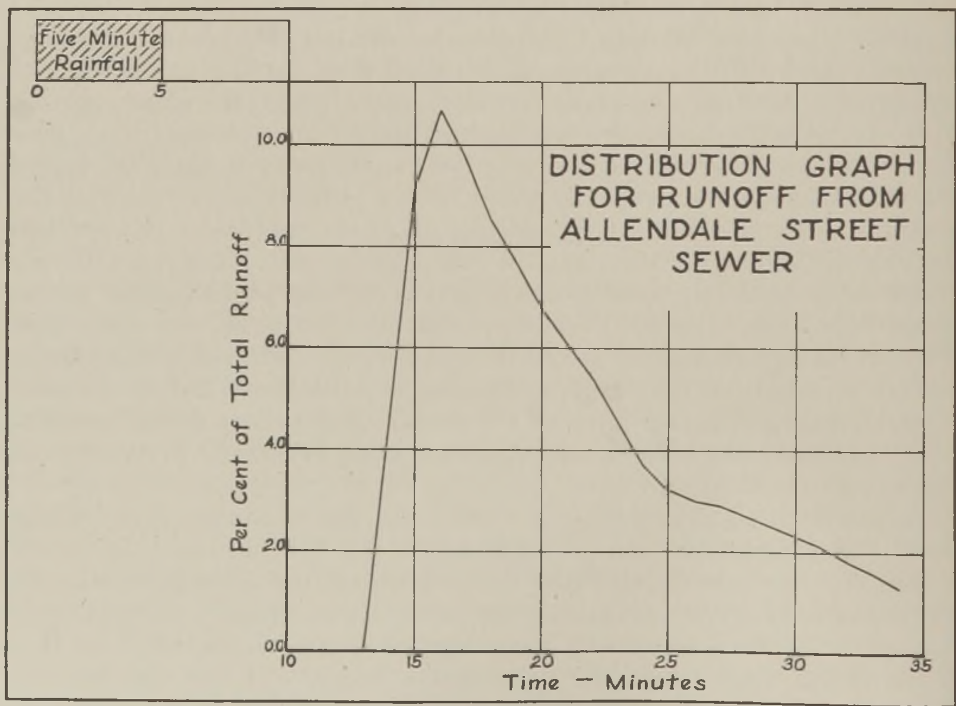


FIG. 7.

synthetic hydrograph were in perfect agreement. A shift of the volume of flow in the synthetic hydrograph showed the necessity of using variable runoff or infiltration coefficients to reproduce the hydrograph exactly. More of the rainfall reached the outlet after short and intense showers. Another factor to be considered is that the impervious portions of the drainage area such as streets, walks, and roofs are responsible for the rapid rise in the actual hydrograph before the runoff from the pervious parts of the area can contribute to the discharge.

Summary

The conclusions to be drawn are not entirely new and are based on only a few storms from a single drainage area. They do represent a type of data of which there is a scarcity in published literature. The problem of the discharge of solids enters into every intercepting sewer design. The most important conclusion is that the amounts of all types of solids discharged are proportional to the discharge. In addition, the short inlet and concentration times should be noted, together with the necessity of using variable infiltration or runoff coefficients to reproduce actual hydrographs.

Acknowledgments

Dr. Abel Wolman and Mr. John C. Geyer of the Sanitary Engineering Department of the Johns Hopkins University directed and assisted in the collection and analysis of the data.

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Sewage Research

PRELIMINARY OBSERVATIONS ON THE EFFECT OF SEWAGE TREATMENT PROCESSES ON THE OVA AND CYSTS OF INTESTINAL PARASITES

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In order to obtain preliminary information which might be of value in connection with the inauguration of a study of the effect of various sewage treatment processes on ova and cysts of intestinal parasites, early in the summer of 1941 one of us (W. H. W.) collected 26 samples of sewage sludge from treatment plants in sixteen municipalities and two national parks in California, and one national park in Arizona. The plants were selected on the advice of Mr. C. G. Gillespie, Chief, Bureau of Sanitary Engineering, California State Department of Health, and Senior Sanitary Engineer H. B. Hommon, U. S. Public Health Service, San Francisco, California. The samples were taken from various types of plants and at various stages during the treatment process. Dried sludge from many of the plants was being supplied directly to farmers or was being disposed of to contractors who in turn mixed it with other fertilizer materials and sold it without further treatment. Later in the summer, through the courtesy of Colonel W. A. Hardenbergh, Office of the Surgeon General, U. S. Army, and Lieutenant Colonel M. J. Blew, Office of the Surgeon, Fourth Corps Area, 75 samples of sludge were obtained from seventeen Army camps in eight southern states, with the view that the generally heavier parasite indices in this part of the country might be more conducive to positive findings. We are greatly indebted to the above-named individuals and to sanitary officers at the various camps for their cordial cooperation.

Method of Examining Sludge Samples

Usually a 10-gram sample of the material was taken for examination, although 5-gram samples or 20-gram samples were used if the sludge was unusually dry or unusually wet. Alternate washing and sedimentation by centrifugation was practiced until the supernatant liquid was clear. Isolation of parasite ova and cysts was then accomplished by centrifugal flotation with zinc sulfate solution of specific gravity 1.180 (1). Later a solution having a specific gravity of 1.250 was employed, since the higher specific gravity was more efficient for the flotation of eggs of *Ascaris lumbricoides* (2). Initially, material found to contain protozoan cysts on microscopic examination was cultured on modified Locke egg medium, as described by Reardon and Rees (3). Later, in order to eliminate possible sources of error, material from all samples was cultured regardless of the results of the microscopic examination.

Helminthological Findings

In the material from Arizona and California, positive findings of parasitic helminth ova were encountered in only one sample, that from the final drying bed of a plant with Imhoff tank and trickling filter at Whittier, California. In this instance, only one egg was found, this being a tapeworm egg of the genus *Hymenolepis*.

Table I.—*Army Camps From Which Samples of Sewage Sludge Were Obtained and Results of Examinations for Parasitic Helminth Ova*

	Number Samples Examined	Number Samples Positive
Alabama		
Camp I	3	0
Florida		
Camp I	3	0
Camp II	6	5
Camp III	1	0
Georgia		
Camp I	4	1
Camp II	5	0
Camp III	3	0
Louisiana		
Camp I	3	0
Camp II	8	3
Camp III	8	7
Camp IV	1	0
Camp V	9	6
Mississippi		
Camp I	4	0
North Carolina		
Camp I	3	1
Camp II	8	4
South Carolina		
Camp I	3	0
Tennessee		
Camp I	3	0
Totals	75	27

As shown in Table I, 75 samples of sludge were examined from the seventeen Army camps in eight southern states with positive findings of parasitic helminth ova in 27, or 36 per cent, of the samples. The species encountered in order of frequency were *Ascaris lumbricoides*, *Trichuris trichiura*, and *Hymenolepis* sp. As in some of the samples from California, there were encountered nematode larvae and ova which were indistinguishable from those of the human hookworm. However, in view of the source of the material and the fact that species of free-living nematodes were found rather frequently, the identity of these larvae and ova was open to question.

Eggs of *Ascaris lumbricoides* were recovered from sludge at all stages of the treatment process. Special emphasis was put on examination of sludge from drying beds in camps from which samples taken earlier in the course of the treatment process were found positive for ova. As will be seen from Table II, 12 of 17, or over two-thirds of the

TABLE II.—*Origin of Samples and Findings of Helminth Ova in 75 Samples of Sewage Sludge from Seventeen Army Camps in Eight Southern States*

Source of Sludge Samples	Number Samples Examined	Number Samples Positive	Helminth Ova Encountered		
			Ascaris lumbricoides	*Ascaris* and *Trichuris*	*Ascaris, Trichuris,* and *Hymenolepis* sp.
Raw Sewage	2	1	1		
Primary Settling Tank	14	3	2	1	
Secondary Settling Tank	9	1		1	
Activated Sludge Return	4	1	1		
Primary Digester	7	3	2	1	
Secondary Digester	9	5	4	1	
Digester (Undesignated)	7	1	1		
Drying Bed	17	12	10	1	1
Imhoff Tank	5	0			
Wet Well Sump	1	0			
Totals	75	27	21	5	1

samples examined from the drying beds, were positive. Five of 9 samples from the secondary digesters also contained eggs of helminth parasites.

Intensive study was made of eggs recovered from the various samples in order to determine whether they had been damaged by the treatment process or whether they still retained their viability. *Hymenolepis* eggs recovered from the drying bed in one case appeared to be normal. *Trichuris* eggs appeared normal after recovery from primary and secondary settling tanks, primary and secondary digesters, and the final drying bed; in one sample collected from the drying bed four hours after deposition of the sludge thereon viability was demonstrated by the development of an active embryo within the egg 22 days after isolation from the sludge. *Ascaris* eggs were usually normal in appearance but in some cases the outer shell appeared to be swollen so that the mammillations were unusually large. In these cases, the protoplasm was not of normal appearance. However, even when these changes had taken place, the viability of the eggs was not destroyed. Eggs of *A. lumbricoides* isolated from 10 samples (1 from activated sludge, 1 from the primary and 2 from secondary digestion tanks, and 6 from drying beds) were cultured in a 1 percent solution of formalin and observed for a suitable period of time. From these cultures, active embryos (Fig. 1) developed, which on removal from the shell were seen to possess characteristics of fully-developed infective embryos. This was true for ova recovered from sludge in the earlier stages of treatment, in sludge samples at the time of removal of the sludge to the

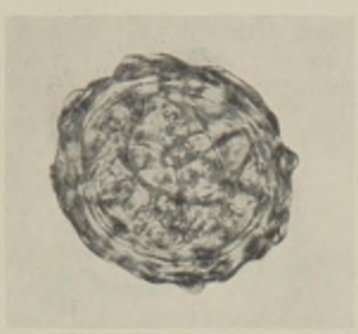

FIG. 1.—*Ascaris lumbricoides* ovum, with living embryo, 42 days after recovery from a primary digestion tank.

drying bed, and in that which had been on the drying bed for as long as 62 days. Continued activity in the eggs for as long as 66 days after embryo motion was first noted gave evidence that the vitality of the embryos had not been impaired by the sewage treatment process.

Table III summarizes the data concerning the positive findings of helminth ova secured in various kinds of sludge samples from the different camps. There was no particular correlation between the type of treatment process and positive or negative findings of parasite eggs in the sludge samples. In some camps, summer maneuvers interfered with the collection of samples and for this reason more samples were obtained from some camps than from others. It is possible that differences in results of examinations of material from various camps were related, at least in part, to the origin of troops occupying the camps with differences in the incidence of intestinal parasites. However, for military reasons, it was not considered feasible to inquire into the matter.

PROTOZOOLOGICAL FINDINGS

Protozoan cysts were relatively common in the sludge samples from California. In all but a few cases active amoebae were subsequently found in cultures both at incubator temperature of 37° C. (98.6° F.) and at room temperature.* Free-living amoebae in mounts stained with iron haematoxylin were usually readily distinguishable from *Endamoeba histolytica*. However, in a sludge specimen collected from the bottom of a final digestion tank in California, cysts resembling those of *E. histolytica* were recovered. A good growth of the amoebae was

* The mean temperature recorded by the Weather Bureau in nearby Washington, D. C., for this period was 82.6° F., the highest being 96° F., and the lowest 54° F. The temperature range in the laboratory probably did not go quite so high or so low.

TABLE III.—*Positive Findings of Helminth Ova in Various Types of Sewage Sludge in Different Army Camps in the Southern States*

Name of Camp	Origin of Sludge Sample	Helminth Ova Encountered				Length of Time on Drying Bed
		Ascaris lumbricoides	*Trichuris trichiura*	*Hymenolepis* sp.	Hookworm	
Florida, Camp II	Raw Sewage	x				
	Activated Sludge Return	x				
	Digester	x				
	Drying Bed	x				2 samples; 13 and 62 days, respectively
Georgia, Camp I	Secondary Digester	x				
Louisiana, Camp II	Primary Settling Tank	x				
	Drying Bed	x	x			4 days
	Drying Bed	x				6 weeks
Louisiana, Camp III	Primary Settling Tank	x	x		?	
	Primary Settling Tank	x				
	Secondary Settling Tank	x	x		?	
	Primary Digester	x				
	Primary Digester	x	x			
	Secondary Digester	x	x			
	Drying Bed	x				4 to 6 weeks
Louisiana, Camp V	Secondary Digester (2 Samples)	x (in each)				
	Drying Bed	x				3 samples; 2, 21, and 22 days, respectively
	Drying Bed	x	x	x		4 hours
No. Carolina, Camp I	Secondary Digester	x				
No. Carolina, Camp II	Primary Digester	x				
	Drying Bed	x				3 samples; 1 sample 55 days; others unknown

obtained in cultures made in June * and held at incubator and at room temperatures. The trophozoites appeared to reproduce in cultures as readily at room temperature as at incubator temperature. Permanent stained mounts which were studied later indicated that the trophozoites from these cultures resembled morphologically those of *E. histolytica.* We have been able to maintain cultures of *E. histolytica* at 86° F. over a period of 34 days, and in the subcultures the trophozoites remained active and slowly multiplied. However, at a temperature varying from

* During the period of culture, Weather Bureau records indicated variations in temperature from 60° F. to 87° F. with a mean of 72° F. See previous footnote.

72° to 78° F., activity was noted for only three days and by the sixth day the trophozoites had died out in the cultures.

Active amoebae developed both at room temperature and at incubator temperature in cultures made from the sludge samples from the Army camps. *Dimastigamoeba gruberi, Hartmanella hyalina* and *Vahlkampfia* spp. were identified from the cultures in accordance with the descriptions of Lackey (4), Wenyon (5), and Kudo (6). The first named organism was seen both in the amoeboid and flagellate stages in culture and on stained preparations. However, as in the sludge sample from California, there was found an organism morphologically resembling *E. histolytica.* This form was present in cultures prepared from sludge from a primary digestion tank at Camp III, Georgia, a secondary digestion tank at Camp I, Georgia, and an Imhoff tank at Camp IV, Louisiana. Although present in cultures maintained both at room temperature and at 37° C., it appeared more numerous in those at room temperature.

Discussion

To our knowledge, no previous investigations have been carried out in this country relative to the effect of sewage treatment processes on ova and cysts of intestinal parasites. A search of the literature failed to reveal information on this point and inquiry among leading sanitary engineers resulted in negative replies. In view of the utilization of sewage sludge as fertilizer in various parts of the United States and the possible increased employment of this material as more nitrates are required for explosives manufacture, it appeared worth while to institute the preliminary investigations described in this paper. After the examinations had begun, the results of investigations in Soviet Russia by Vasilkova (7) and in Brazil by Amaral and Leal (8) came to our attention. The findings of these investigators will be discussed in detail in a later paper which will report results of studies carried out in small-scale treatment plants. However, our preliminary observations are in agreement with those of the above-mentioned workers and indicate that ova of parasitic helminths, particularly those of *Ascaris lumbricoides,* may remain viable after passing through various treatment stages of sedimentation, digestion, and drying.

The species of amoeba which we were unable to distinguish morphologically from *Endamoeba histolytica* appears to answer the description of a new form found in sewage waters in Russia and described by Chalaya (9) as *Endamoeba moshkovskii.* According to this author, quadrinuclear cysts of this species, not distinguishable from the cysts of *E. histolytica,* were found frequently in the sewage waters of the Moscow River. Chalaya was able to obtain good growth of the vegetative forms in cultures maintained at 15° to 37° C. He considered the amoeba to be a free-living form adapted to specific polysaprophytic conditions. While we failed to isolate *E. histolytica* from the sludge samples, there is still the possibility that cysts of this species may occur in sewage sludge and further work is being conducted on the problem.

Summary

Preliminary observations on the effect of sewage treatment processes on the eggs and cysts of intestinal parasites were carried out through the examination of 26 samples of sewage sludge from sixteen municipalities and two national parks in California and one national park in Arizona, as well as of 75 samples obtained from seventeen Army camps in eight southern states. The material from the Southwest was negative for parasitic helminth ova with the exception of the finding of an egg of *Hymenolepis* sp. in one of the samples. However, eggs of parasitic helminths were isolated from 27, or slightly over one-third, of the samples obtained from the Army camps. Eggs of *Ascaris lumbricoides* were encountered most frequently but those of *Trichuris trichiura* and *Hymenolepis* sp. were also isolated. Ova were found in samples obtained from all stages of treatment from raw sewage to the final dried product. The viability of ova recovered during the various stages was demonstrated. The evidence obtained indicated that the use of sewage sludge as fertilizer may serve to disseminate ova of the intestinal parasites named.

A species of amoeba morphologically similar to *Endamoeba histolytica,* but having different cultural requirements, was found in sludge from digestion tanks and an Imhoff tank. This species is closely related to *Endamoeba moshkovskii* described by Chalaya (9) in sewage waters at Moscow. Failure to locate *E. histolytica* in the samples examined does not rule out the possibility of its occurrence in sludge and the matter is receiving further attention from an experimental standpoint.

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DISTILLERY WASTE TREATMENT BY ELECTRODIALYSIS *

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During the last nine years extensive studies have been made on the value of electrodialysis in sewage and waste treatment. It has been found that suspended solids in sewage can be made more amenable to coagulation by electrodialyzing the sewage in the cathode compartment for 15 minutes, using sewage sludge in the anode compartment (4). By this method equal coagulation was obtained on sewage with one-third to one-half of the chemical ordinarily required when the sewage was not electrodialyzed. Distillery slop does not contain large quantities of suspended solids and is difficult to treat by chemical coagulation. The object of the studies was to reduce the oxygen demand of the wastes sufficiently to permit their introduction into a stream or sewage treatment plant and to determine whether electrodialysis would be effective at some stage of treatment.

The experimental work on distillery slop included three general methods of treatment:

(*a*) Chemical coagulation.
(*b*) Chemical coagulation plus biological treatment.
(*c*) Electrodialysis with and without chemical or biological treatment.

This paper deals primarily with the studies under (*c*).

Material and Analytical Methods

The type of waste experimented with might be termed the de-alcoholized wort from the manufacture of alcohol from crude molasses by acid fermentation. Essentially, the waste consists of the residue from the distillation of the fermented molasses. This spent residue, "distillery slop" or "beer slop," is discharged continuously during the distillation process from the beer still at a temperature of 180° to 200° F.

Large samples of distillery waste were obtained from the Baltimore and Newark distilleries of the U. S. Industrial Alcohol Company. Analyses made on the materials are given in Table I. The oxygen consumed values of various fractions of the Newark wastes were as follows:

Sample	*P.P.M.*
Raw slop	70,750
Fraction through filter paper	60,000
Fraction through Gooch filter	56,250
Fraction through Seitz filter	53,750

* Journal Paper, New Jersey Agricultural Experiment Station, Department Water and Sewage Research.

The main constituents of this type of waste are proteins, potash, phosphates and unfermentable sugars. The B.O.D. values (Table I) indicate very high contents of biologically oxidizable organic material, with a very large part of the organic matter in dissolved form. The fraction through the Seitz filter (soluble) constituted about 76 per cent of the total oxygen consumed value of the slop.

TABLE I.—*Analyses of Distillery Wastes*

	Baltimore	Newark
Total Solids, per cent	7.58	9.17
Volatile Solids, per cent	75.4	75.1
O.C., p.p.m.	68,000	70,000
5-day B.O.D., p.p.m.	35,000	37,000
Acidity, M.E./liter	138	120
Alkalinity, M.E./liter	218	200
Total N (wet basis), p.p.m.	2,285	—
NH_3–N (wet basis), p.p.m.	80	—
pH	4.8	4.8

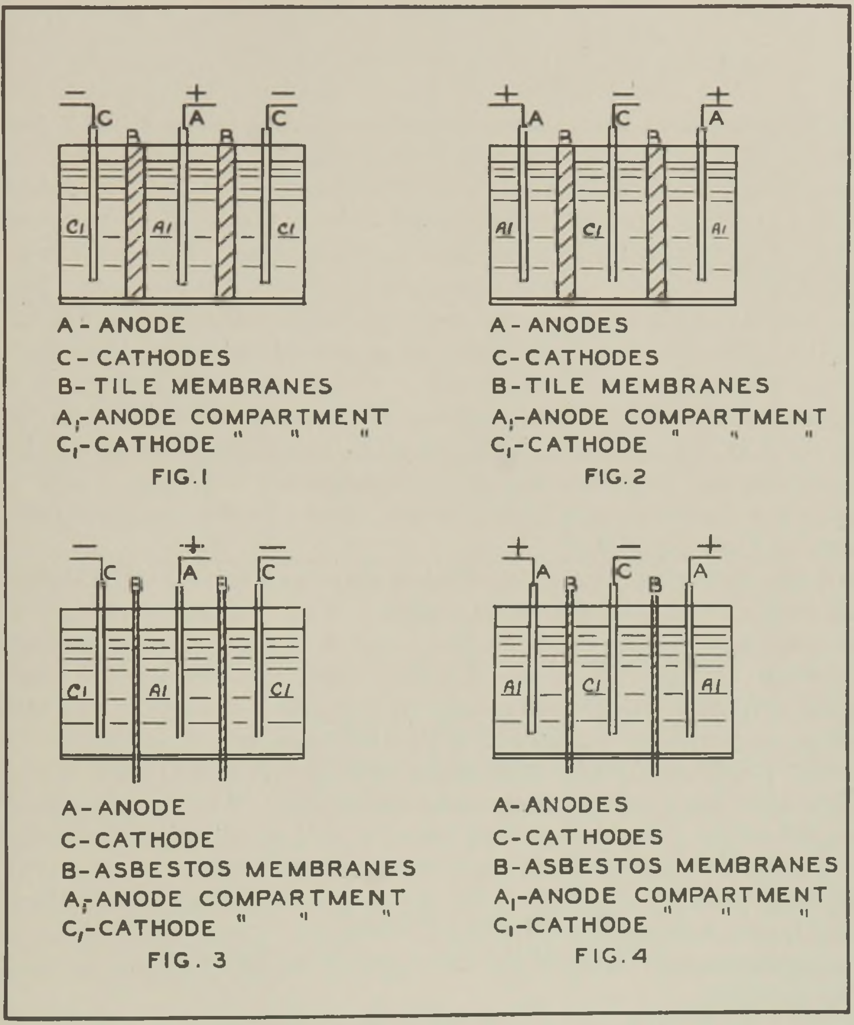
The barrels with distilling wastes were stored at 35–40° F. to prevent further fermentation or souring. During the experimental work the analyses most frequently made were those for oxygen consumed, B.O.D., pH, and filtrability of sludge. The methods used were in accordance with the Standard Methods of the A. P. H. A. (5), except that in the O.C. determinations the strength of the $KMnO_4$ and oxalic acid used was five times the strength specified in Standard Methods. The B.O.D. samples were properly seeded with filtered sewage. A comparison of the 5-day 20° C. B.O.D. and O.C. values indicates that the B.O.D. as determined was about 55 per cent of the O.C. value. This is probably due to the organic material not readily attacked by the biological flora but rapidly oxidized by the acid $KMnO_4$ solution.

The rate of filtrability was determined by adding to 100 c.c. of the sludge 10 c.c. of tap water and filtering through a Buchner funnel, using Sergent No. 500 filter paper at a vacuum of 21 inches mercury. The number of c.c.'s of liquid filtered per minute was recorded as well as the point at which the filter cake cracked or a dry cake was obtained. The per cent solids in the filter cake was determined.

General Procedure of Experimentation

Early in our work it was found that it would be difficult to treat the concentrated slop biologically and with chemicals. The time required for biological treatment was excessive and the loadings relatively small. The quantities of chemicals required were extremely large, causing difficulty in mixing and coagulation, and producing a very slowly settling and compacting floc. For most of the work the slop was diluted to 10 per cent of its original concentration. Chemical treatment followed closely lines of best practice for sewage treatment. For biological treatment the activated sludge process was used.

The experimental work has been divided into two general series of tests: (1) Electrodialysis with tile membranes, and (2) electrodialysis with asbestos membranes. The electrodialysis tests of Series I were conducted with three-compartment cells as shown in Figs. 1 and 2. The cells had slate bottoms and glass sides. The membranes, which



FIGS. 1 to 4.—Cells and arrangements used for electrodialysis.

were refractory tile (1½ in. thick), were held in place by cement. The capacity of the cell was roughly 9 liters, 3 liters for each compartment. In this series of tests, the time of electrodialysis was varied. When the electrodialysis treatment was used entirely for the purpose of making the slop amenable to further treatment, either biologically or chemically, or a combination of both, the time for electrodialysis was limited to 2 to 2½ hours.

The refractory tile membranes were structurally strong and gave good results, but caused a power loss across the membranes equal to approximately 80 per cent of the total power input to the cell. In this series only Baltimore slop was used.

The tests in Series II were run with a three-compartment cell using woven asbestos cloth membranes of the same type as those used in commercial chlorine cells. The cells were made from large composition battery boxes cut into three individual sections, as shown in Figs. 3 and 4. The membranes were placed between the sections, which were held together by a clamping arrangement, using rubber gaskets to make the assembly water tight. Electrodialysis was carried on during long periods to produce complete flocculation without chemicals and the yielding of a filtrable sludge with a fairly clear supernatant liquor. The material treated was Baltimore and Newark slop. On account of the higher content of total and soluble matter in the Newark slop, slightly different methods were used with the same equipment.

All of the electrodialysis tests were run at relatively low voltages (12 to 24 volts) and at currents up to 2 amperes. No effort was made to operate at the most economical current density. Graphite electrodes were used at the cathode. In most tests, the diluted slop was electrodialyzed in the cathode (center) compartments with tap water (with or without chemical additions) in the anode (end) compartments, as shown in Figs. 2 and 4.

In the biological tests the diluted slop was mixed with equal volumes of thin returned activated sludge. The original sludge used was collected from an activated sludge plant, but the material was unable to produce purification of the distillery slop in a reasonable time. A specific activated sludge was gradually built up (ten days to two weeks), capable of oxidizing the slop in reasonable periods of aeration.

The most important difficulties encountered with the activated sludge were foaming and disintegration of floc. The foaming was pronounced when aeration started, even with low air flow, but subsided and gradually disappeared when the material became partly oxidized. With long periods of aeration the floc began to break up and dispersed in the liquor, interfering with rapid settling. The dispersed floc could be coagulated and settled by addition of small dosages of alum or ferric chloride.

Results, Series I

Series I includes results obtained by electrodialysis of Baltimore slop and various combinations of chemical treatment, biological treatment and electrodialysis.

Aeration.—Mixtures of diluted slop and activated sludge were aerated for a number of hours and the effluent analyzed at intervals. Results of a typical test (Fig. 5) show that the O.C. value was reduced from 6,800 to 1,450 p.p.m. in 8 hours, and to 812 p.p.m. in 22 hours.

Accompanying the reduction in O.C. the pH values changed from 4.8 to 7.2 after 8 hours and to 7.8 in 22 hours aeration.

Chemical Treatment Followed by Aeration.—Addition of 480 p.p.m. Fe (added as $FeCl_3$) to diluted slop produced good flocculation and fairly rapid settling. The O.C. of the settled effluent was reduced from 6,800 p.p.m. to about 3,000, or 55 per cent. The settled sludge was mixed with activated sludge and aerated for 23½ hours. Samples taken at intervals showed that the O.C. values were reduced to 830 p.p.m. in 6 hours, after which the rate of reduction dropped off (Fig. 5). At

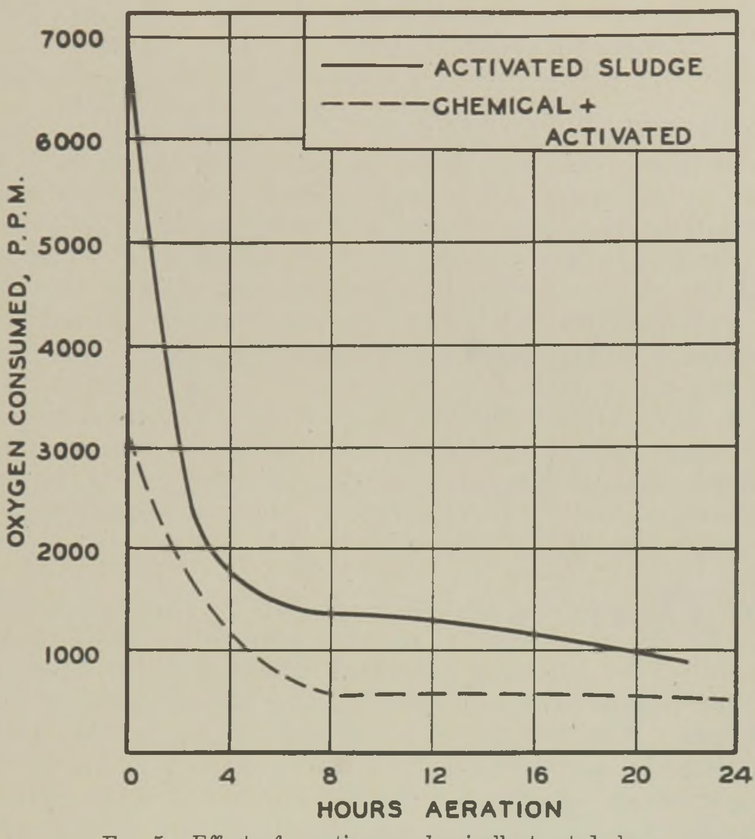


FIG. 5.—Effect of aeration on chemically treated slop.

the end of the aeration period the O.C. of the effluent amounted to 500 p.p.m., or a 92.6 per cent reduction. Repeated experiments showed this to be about the point where the material resisted further oxidation, regardless of the type of treatment employed.

Dialysis.—The object of the experiments was to obtain information regarding the degree of oxidation or reduction which could be obtained by electrodialysis of untreated diluted slop. The time of dialysis was, in all cases, 2 to 2½ hours with the following electrical conditions: average voltage 16 to 17 volts, average current 0.46 to 0.50 ampere. Results of two typical tests, one in which the slop was placed in the anode (center) compartment (Fig. 1), and the other in which the slop was placed in the cathode (end) compartment (Fig. 2) are shown in Table II. During the 2½ hours dialysis very little reduction in O.C. occurred.

TABLE II.—*Effect of Dialysis*

Test	Location of Slop	Before		After		Red.
		pH	O.C.	pH	O.C.	
			P.p.m.		P.p.m.	Per Ct.
3a	Anode	4.8	6,800	4.0	6,450	5.1
3b	Cathode	4.8	6,800	6.6	6,500	4.4

Dialysis Followed by Aeration.—The object was to determine whether dialysis treatment made the slop more amenable to further treatment by aeration. After dialysis for 2 hours the slop was mixed with activated sludge and aerated for a total period of 24 hours. The results obtained showed reduction in O.C. values about equal to those obtained by aeration alone. It appeared that dialysis in either the cathode or the anode compartment for short periods did not make the slop materially better suited for biological treatment. The reduction in O.C. was rapid during the first 4 to 6 hours' aeration. The pH values of the material dialyzed in the cathode compartment were raised to about 6.6, giving it a slight advantage over the slop dialyzed in the anode compartment. This was indicated by the percentages O.C. reduction after 4 hours' aeration, which amounted to 75.5 and 71 per cent respectively. The advantage was limited to short time aeration.

Chemical Treatment Followed by Dialysis.—The purpose of these experiments was to determine whether removal of most of the suspended matter by chemical treatment would make the liquor more suitable for treatment by dialysis in either the anode or the cathode compartment. The slop was treated with 460 p.p.m. Fe (as $FeCl_3$). After flocculation and settling the liquor was dialyzed for 2 hours at an average voltage of 22.9 and average current of 0.44 ampere. Results showed that practically no further reduction of O.C. occurred during dialyses.

Chemical Treatment Followed by Dialysis and Aeration.—Typical results obtained by chemical treatment (460 p.p.m. Fe), dialysis (2 hours) and aeration are illustrated in Fig. 6. The pH of the slop (4.8) was lowered to 3.4 after chemical treatment and to 3.1 after dialysis in the anode compartment, whereas in the cathode compartment the pH of the liquor increased again to 4.7. The indication that consistently better results are obtained during aeration of liquor treated in the cathode compartment may be due to the difference in acidity. Biological action improved when the pH rose toward neutrality. However, even in the case of cathode treated material followed by aeration, the O.C. reduction was not appreciably greater than that obtained when chemical treatment was followed by aeration.

Dialysis Followed by Chemical Treatment and Aeration.—Sewage and wastes containing suspended materials are made more amenable to coagulation after a short period of dialysis. Diluted slop was dialyzed in the anode compartment against tap water in the cathode compartments and other batches in the cathode compartment. The

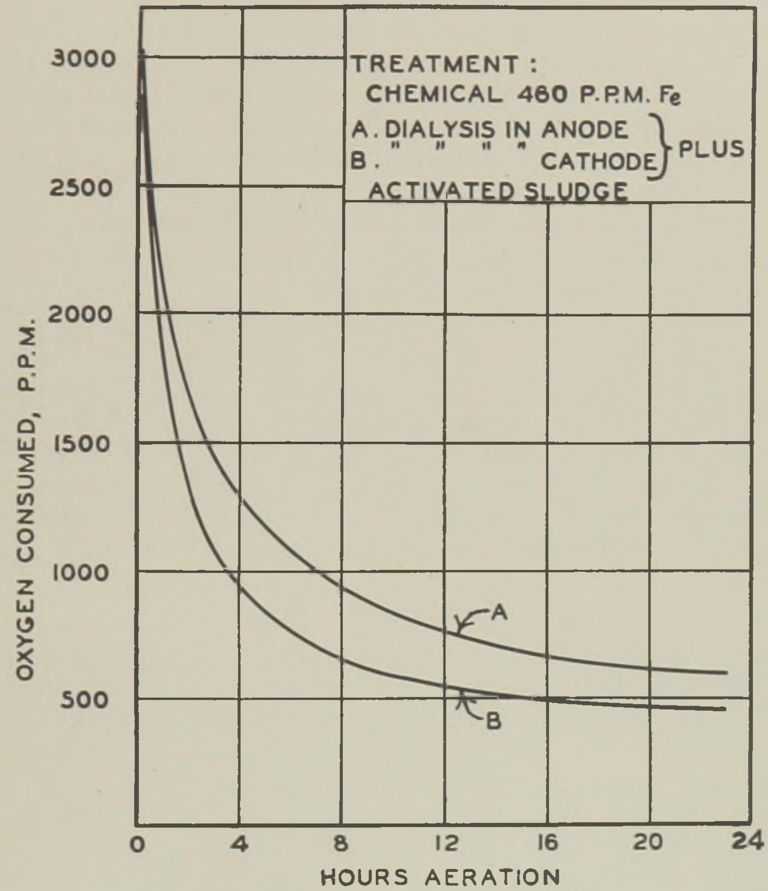


FIG. 6.—Effect of dialysis and aeration on effluent from chemically treated slop.

anodic and cathodic dialyzates were coagulated with $FeCl_3$, settled, and the liquors aerated after mixing with activated sludge. Typical results show that, after dialysis in the anode compartment, the O.C. reduction amounted to about 15 per cent, whereas the cathodic reduction was only a little over 6 per cent. After dialysis, the chemical requirements were not materially lowered of either the cathodic or anodic dialyzates. Aeration of the anodic supernatant liquor for 8 hours, after chemical treatment, lowered the O.C. value to an average of 1,020 p.p.m., whereas the cathodic liquor was reduced to an average of 880 p.p.m. After 23 to 24 hours aeration the O.C. was reduced to

470–635 p.p.m., indicating again that an organic material very resistant to oxidation was present.

Coagulation, Aeration Followed by Chlorination and Electrolysis.—Since a rather definite amount of resistant organic matter was left in the effluent of the material treated by various combinations, it was thought that chlorine discharged at the anode might result in the oxidation of the residual organic matter. After chemical treatment, the supernatant was treated for 8 hours by aeration and subsequent settling of the sludge, and the effluent was placed in the anode (center) compartment of the cell with a NaCl solution (100 gr. NaCl/liter) in the cathode compartments. The dialysis (chlorination) was carried out at an average voltage of 14 volts and an average current of 0.6 ampere. The results showed a total reduction of O.C. after aeration to 755 p.p.m. (88.8 per cent) with a further reduction to 590 p.p.m. The results substantiated previous work that chlorination was not very effective in oxidizing the residual organic matter at laboratory temperatures and during relatively short periods of contact.

Coagulation, Aeration, Dialysis and Secondary Coagulation.—These tests were combinations of all of the methods used previously. The diluted slop was coagulated with 460 p.p.m. Fe (as $FeCl_3$), aerated for 8 hours, dialyzed in the anode compartment, and the dialyzate again treated with $FeCl_3$ (230 p.p.m. Fe). The results showed no appreciable reduction in O.C. after 8 hours aeration by dialysis or secondary chemical treatment. The O.C. value of 725 after aeration was reduced only to 665 p.p.m. by dialysis and secondary coagulation.

Comparison of Results

In order to determine the comparative value of the different methods employed in the treatment of distillery slop, the more pertinent results are summarized in Table III. For an evaluation of the effect of dialysis alone or in conjunction with chemical and biological treatment the results are of interest. With chemicals alone the maximum O.C. reduction that could be obtained amounted to about 55 per cent, or somewhat higher than that obtained by complete physical removal (Seitz filter) of suspended solids. This indicates that chemical treatment is limited almost entirely to the material represented by the coarse and colloidal substances (coagulation). In this respect, it is noted that the molasses slop responded better to coagulation and more rapid settling of sludge when diluted.

Treatment of the diluted waste by short-time electrodialysis, using tile membranes, had very little direct value as far as O.C. reduction was concerned. On account of the high power loss over these membranes, little actual energy was free for transporting ions, with the result that pH changes resulting from dialysis were not appreciable, nor did it bring the slop to the pH range where it could be coagulated with reduced chemical dosages. With sewage, dialysis for 15 minutes in the cathode compartment was sufficient to effect a one-third to one-

TABLE III.—*Summary of Results on Diluted Slop*
(Dialysis With Tile Membranes, 2–2½ Hours)

Order of Treatment	Hrs. Aeration	O.C. Effl.	Red. O.C.	Final pH
		P.p.m.	Per Cent	
None	0	6,800	—	4.6
Activated Sludge	8	1,450	78.6	7.2
	22	812	88.1	7.8
Coagulation—Act. Sludge	8	600	91.0	5.4
	23.5	500	92.5	5.6
Dialysis (Anode)	0	6,450	5.1	4.0
Dialysis (Cathode)	0	6,500	4.4	6.6
Dialysis (Anode)—Act. Sludge	8	1,440	78.9	7.0
	24	910	86.5	7.3
Dialysis (Cathode)—Act. Sludge	8	1,460	78.5	7.3
	22	935	86.4	7.9
Coagulation—Dialysis (Anode)	0	3,000	55.8	3.1
Coagulation—Dialysis (Cathode)	0	3,030	55.5	4.7
Coagulation—Dialysis (Anode)—Act. Sludge	7.5	920	86.4	4.9
	23	658	90.2	5.0
Coagulation—Dialysis (Cathode)—Act. Sludge	7.5	650	90.5	5.7
	23.5	470	93.0	6.0
Dialysis (Anode)—Coagulation—Act. Sludge	8	1,020	85.0	6.0
	16	780	88.5	6.2
Dialysis (Cathode)—Coagulation—Act. Sludge	8	880	87.0	—
	23	835	90.6	6.5
Coagulation—Act. Sludge—Chlorination by Electrolysis	8	590	91.3	2.0
Coagulation—Act. Sludge—Dialysis (Anode) 2nd Coagulation	8	665	90.2	2.9
Coagulation	0	3,060	55.0	3.5

half reduction in chemical demand. It appears that unless coagulation of the slop is effected during dialysis, little direct O.C. reduction can be expected, because the amount of actual oxidation at the anode or reduction at the cathode is not appreciable.

The combination of chemical coagulation followed by dialysis in either the anode or the cathode compartment did not appear practicable. Assuming that nearly all the colloidal matter is coagulated with relatively large dosages of chemicals, further reduction in O.C. by the subsequent dialysis would have to result from oxidation or reduction of the dissolved organic matter. This process is theoretically feasible, but at best would be very protracted and require considerable energy expenditure, as the oxidation would probably follow stoichiometric relationships.

In treating the distillery waste by aerobic organisms effectively and fairly rapidly, at least two major conditions must be provided: (1) dilution and (2) a balanced biological community. The latter must be developed either on filters or in activated sludge. Properly conditioned activated sludge was capable of reducing the O.C. of diluted slop by about 78 per cent in 8 hours and 88 per cent in 22 hours. It is conceivable that a much more rapid oxidation rate could be obtained during the first 8 hours if methods of concentration and return of an active sludge were utilized.

Coagulation with 460 p.p.m. Fe followed by activated sludge gave fairly good results, but continuous operation would require the raising of the pH value after coagulation to prevent retardation of biological activities by the accumulation of acids.

Dialysis for short periods followed by activated sludge did not produce an appreciable decrease of O.C. over activated sludge alone, although the effect of dialysis (especially in the cathode) was to raise pH values. Increase of pH values may be accomplished by other means than electrodialysis. Dialysis in the anode compartment caused a lowering of pH values and no appreciable increase in O.C., so that a combination of anode dialysis and activated sludge would be detrimental to the biological process.

Secondary coagulation after activated sludge treatment accomplished only minor reduction of O.C. This treatment might be beneficial with thin and voluminous sludge or when the sludge settles poorly. Such beneficial effects were found a number of times in our studies.

The best results were obtained with a combination of treatments, consisting of coagulation followed by dialysis in the cathode and then activated sludge. The lowered pH value caused by chemical treatment was raised by cathodic dialysis, aiding biological treatment and resulting in over 90 per cent reduction in O.C. after 7.5 hours' aeration.

It is well known that proteinaceous material, slaughterhouse and meat packing plant wastes can be coagulated to a large extent by properly applied chlorination. Halverson, Cade and Fullen (2) report B.O.D. removal of 85 per cent by super chlorination of proteinaceous material, and Eldridge (1) was able to remove 90 per cent B.O.D. of packing plant waste by chlorination. In our studies it was found that after coagulation and oxidation, the evolution of nascent chlorine resulting from electrolysis of a brine solution caused a further reduction of the remaining O.C. value of 22 per cent. The very high residual chlorine apparently oxidized some of the soluble material left, but, as might be expected, was ineffective to change the resistant carbonaceous materials. The material was, however, thoroughly bleached and appeared very stable, showing no growth or signs of fermentation after standing for several months, although the O.C. value was 590 p.p.m.

Results, Series II

(A) Baltimore Slop

Electrodialysis tests on Baltimore slop were made, using asbestos membranes in three-compartment cells as shown in Figs. 3 and 4. Experiments on the Newark slop were made with the arrangement shown in Fig. 4. For convenience of presentation, the results obtained on these two types of slop are kept separate. Whereas the previously presented tests with tile membranes were run with dialysis periods of 2 to 2½ hours, for those conducted with asbestos membranes the dialysis period was frequently prolonged to 24 hours. Preliminary results showed that no appreciable beneficial results could be obtained by dialyzing the slop in the anode compartment, but when dialyzed in the cathode compartment flocculation of the material began after 3 to 4 hours' dialysis. During dialysis, the average voltage was 16.8 volts and the average current 0.66 ampere.

When the asbestos membranes were used for the first time, very good flocculation occurred in 3 to 4 hours, but on subsequent tests longer periods of dialysis were required to produce equivalent flocculation. This difference was considered to be due either (*a*) to a solution of soluble salts with which the membrane was impregnated and which salts aided coagulation, or (*b*) to a change in the nature of the membrane on account of a thin film of material deposited upon it. Various treatments were given the membrane to remove deposited film, including boiling water, washing with alcohol, hot air drying (103° C.) and reversing of current. These treatments aided in restoring the membrane to its original condition. The results obtained with cleaned membranes showed differences in time required to reduce equal percentages of O.C. during the first few hours, but were fairly close after 8 hours' dialysis, except in the case of membranes cleaned with alcohol. Hot air drying was best. By adding various salts to the anodic tap water in order to use the cations of these salts as flocculating agents, it was possible to produce results even better than with new membranes.

Dialysis.—Typical results obtained after 24 hours' dialysis with asbestos membranes, treating the waste in the cathode compartment with the arrangement as shown in Fig. 4, are summarized in Table IV.

TABLE IV.—*Dialyses With Asbestos Membranes*

	Dialyzate				Sludge
	Anodic		Cathodic		
	Begin	End	Begin	End	
pH	7.3	2.6	4.4	10.4	—
O.C., p.p.m.	0	1,300	5,000	810	8,950
Total Solids, per cent	.039*	.15	.687	28.4	2.79
Ash, per cent	23.8*	5.35	.138	39.5	55.2

* After 1 hour.

The pH values of the waste in the cathode compartment rose rapidly during the first hour of dialysis, while the O.C. decreased. The various changes which occurred during 24 hours' dialysis are graphically shown in Fig. 7. The average voltage employed was 12.3 and average current 1.73 amperes. Flocculation occurred after 4½ hours' dialysis, rapidly increasing during the next few hours. After 24-hour dialysis, the flocculated material was allowed to settle, the supernatant liquor was clear but had a yellowish color.

Several features of the results are of interest. While the oxygen consumed value of the waste decreased rapidly, the O.C. of the tap water increased, so that after 24 hours' dialysis it had an O.C. value higher than that of the treated waste. This increase in O.C. was due to the movement of dialyzable organic acids to the anode. The migration of the organic acids was apparently accompanied or followed by movement of inorganic material. The color of the anodic dialyzate changed from light brown after 1 to 2 hours' dialysis to dark brown, and thus also indicated the movement.

The reduction in total solids in the cathode compartment was primarily due to coagulation, but some 15 per cent could be accounted for in the anodic dialyzate. Other work has shown that various inorganic substances migrate through the membranes in a definite order. The increase in ash content of the cathodic dialyzate indicates that removal of organic material from the liquor was relatively greater than the removal of inorganic salts.

In connection with the movement of the various substances, there was a noticeable migration of liquid from the anode to the cathode compartment. This migration of liquor amounted to 23.5 per cent of the original volume in the cathode. The migration was very slight during the first few hours but the rate of migration increased with continued dialysis. From the anodic oxygen consumed curve in Fig. 7 it is clear that organic material gradually and persistently migrated to the anode compartment, while liquid moved to the cathode compartment. This phenomenon will be discussed elsewhere in connection with sludge dewatering.

Dialysis with Aid of Salts.—Experiments were made with addition of various types of salts at different concentrations, in order to attempt to reduce the time required for dialysis and to obtain lower O.C. values. Some results obtained with different concentrations of $MgSO_4$ in the anode compartment are illustrated in Fig. 8. The upper curves represent the changes in the cathodic dialyzate and the lower curves refer to the O.C. in the anodic dialyzate. It will be noted that more rapid lowering of the O.C. was obtained with $MgSO_4$; however, additions of $MgSO_4$ in excess of 200 p.p.m. showed no further improvement. It is of interest to note that lower reduction of O.C. after 24 hours' dialysis without $MgSO_4$ was accompanied by higher O.C. values in the anodic dialyzate as compared with the salt-treated water.

Other salts, such as $MgCl_2$, $FeCl_3$ and $Al_2(SO_4)_3$ were used and the results showed that in most cases the O.C. value of the treated slop was almost identical for an equal number of hours of dialysis. For example, with 8 hours' dialysis, the O.C. value of 4,975 p.p.m. for the diluted slop was reduced to 1,170 without salt and to 985 p.p.m. with $FeCl_3$. After continued dialysis for 24 hours, the differences in O.C. values varied only slightly. The order of effectiveness of the salts was $FeCl_3$, $MgCl_2$ and alum, respectively. The O.C. values in the anodic

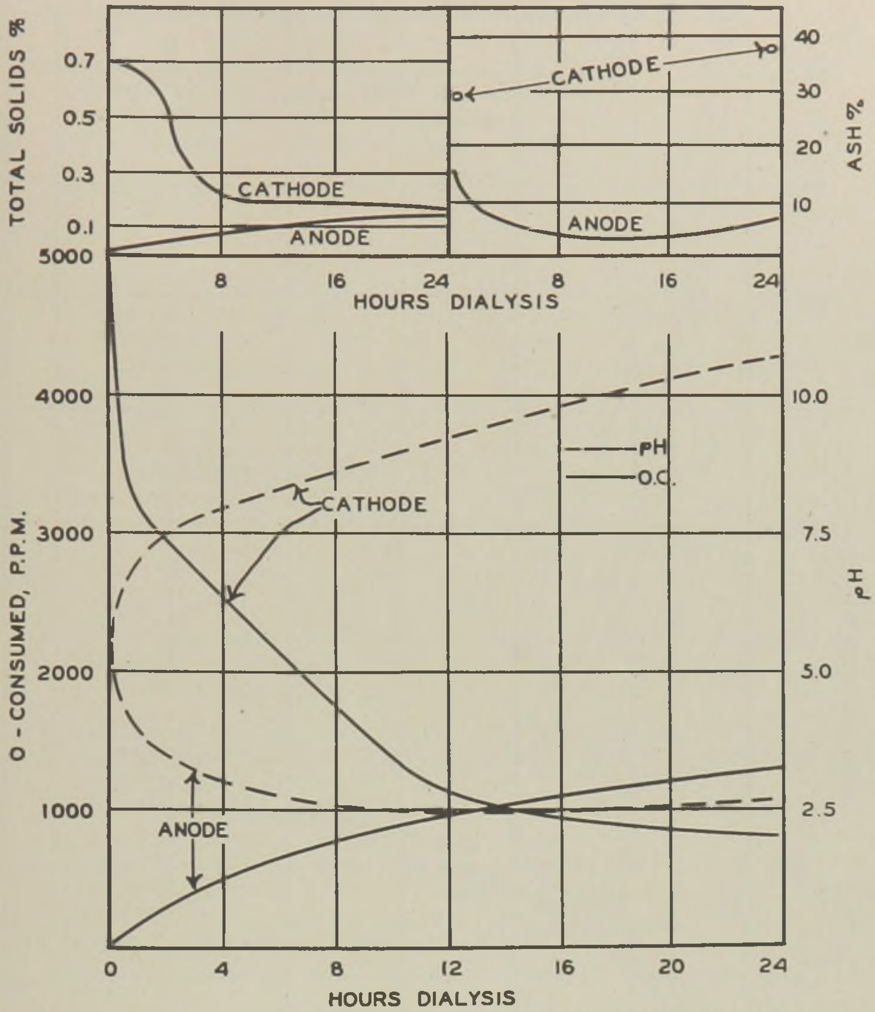


FIG. 7.—Changes occurring during dialysis in the anode and cathode compartments.

dialyzate were lowest with the most effective salt and highest with the least effective.

Filtrability of Sludge.—The sludges obtained by dialysis treatment could be readily dewatered without addition of chemicals. As examples, a few results with optimum quantities of salt are presented in Table V. The time required to produce a dry cake and the number of c.c. water removed show that better filtrability was obtained when 200 p.p.m. $MgCl_2$ was used in the anode compartment than when 100 p.p.m. $FeCl_3$ or alum was used. The sludge obtained with 200 p.p.m. $MgSO_4$ in the anode compartment showed almost as good filtrability as with the same amount of $MgCl_2$.

Liquid Migration.—In the course of experimentation, it was found that liquid migration to the cathode was least when new asbestos membranes were used. Upon subsequent use of these membranes

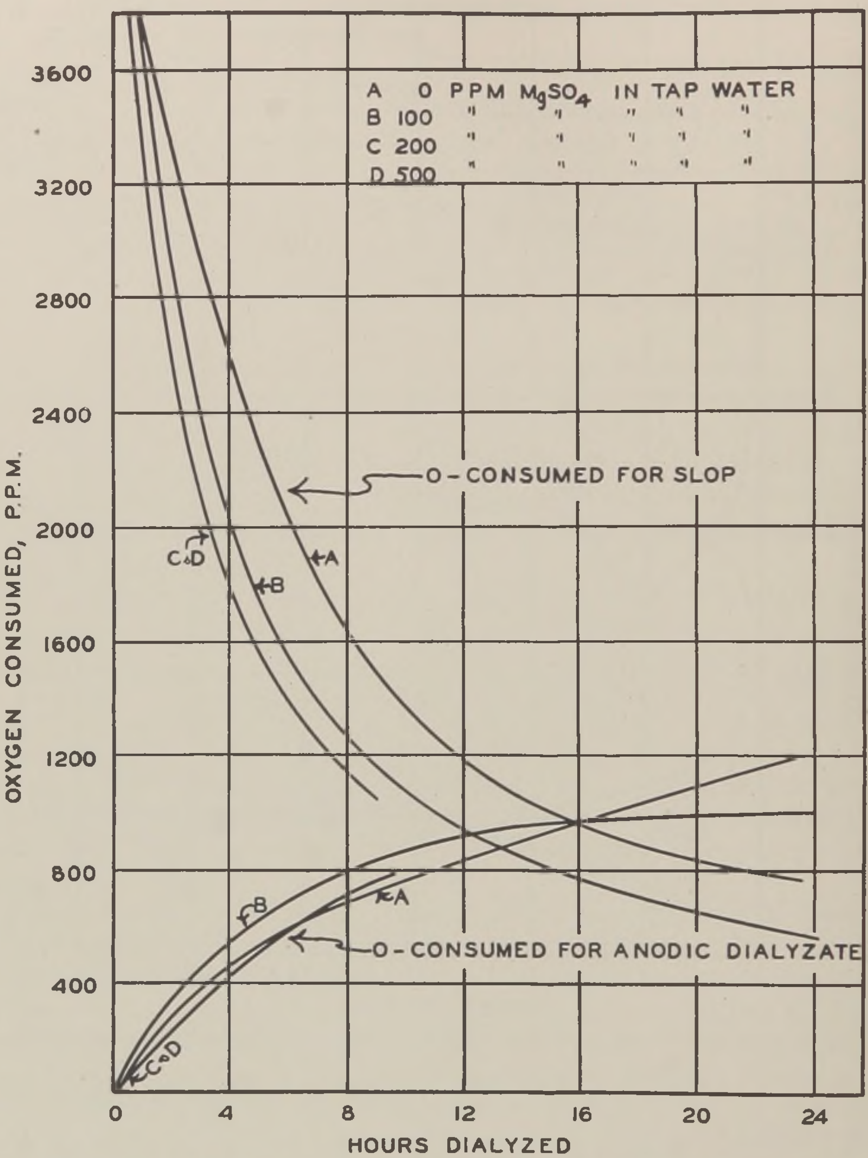


FIG. 8.—Effect of $MgSO_4$ in anodic water on diluted slop with 4,975 p.p.m. O.C.

various quantities of liquid were transported, depending upon the age of the membranes, the type of chemical used in the anodic compartment, and the hours of dialysis. As examples, the percentage increase in cathodic volume during dialysis of different batches are given in Table VI. The highest percentage increase in cathodic volume occurred with $MgSO_4$ added to the anodic water, and the lowest was with $MgCl_2$. The use of new membranes resulted in no migration, but upon continued use the liquid in the cathode compartment gained as much as 16.7 per cent.

TABLE V.—*Sludge Filtrability After Dialysis*

Chemical Added to Anode	Min. Required for Dry Cake	C.c.'s Liquid Removed
None, New Membrane	3	100
$MgCl_2$, 200 p.p.m.	3	100
$FeCl_3$, 100 p.p.m.	7	101
$Al_2(SO_4)_3$, 100 p.p.m.	7	98
$MgSO_4$, 200 p.p.m.	4	103

TABLE VI.—*Liquid Migration to Cathode During Dialysis*

Chemical Added to Anode	Membranes Used	Per Cent Increase in Cathode
None	New	0
$MgCl_2$, 200 p.p.m.	Used	6.25
$Al_2(SO_4)_3$, 100 p.p.m.	Used	15.0
$FeCl_3$, 100 p.p.m.	Used	19.5
$MgSO_4$, 200 p.p.m.	Used	25.0

Reduced Time of Dialysis.—Calculation based upon a number of results indicated that after dialysis of 3 to 4 hours no appreciable reduction in O.C. of the liquids in the system occurred. Continued dialysis resulted in increased O.C. values in the anode compartment; therefore, the reductions in O.C. of the cathodic liquor began to be nearly balanced by the increase in O.C. of the anodic water. This would place the most effective time of dialysis, without chemicals in the anode water, at 3 to 4 hours.

(B) Newark Slop

The Newark slop contained 9.17 per cent total solids as compared with 7.28 per cent for the Baltimore material. About 76 per cent of the O.C. value was contained in the fraction that passed through the Seitz filter.

Anodic and Cathodic Dialysis.—Dialysis with diluted slop (10 per cent) in both the anode and cathode compartments were carried out for periods of 8 hours. The center of the three-compartment cell was used as cathode, while the end compartments were used as anodes. An average of 11.1 volts and 1.45 amperes was used. At the end of 8 hours the anodic dialyzate was reduced from an original value of 7,000 p.p.m. to 6,100 p.p.m., or a reduction of 12.8 per cent. The anodic dialyzate was not amenable to coagulation with the usual chemical dosage. No floc was formed with $FeCl_3$ or alum. The O.C. value in the cathodic dialyzate was reduced by 43.5 per cent. Only a small amount of floc was formed during dialysis, the supernatant remaining turbid. The sludge was not readily filtrable. Although the dialyzate could be readily flocculated, the O.C. value did not decrease more than could be obtained by filtering.

Cathode Dialysis with Salt Solution in the Anode.—Preliminary tests had shown that no appreciable flocculation could be obtained with

8 hours dialysis without the addition of salts. The chemicals used included $MgCl_2$, $CaCl_2$, $Ca(OH)_2$, $SnCl_4$, $ZrCl_4$, $Zr(SO_4)_2$ and $FeCl_3$. Best results were obtained with $MgCl_2$, $CaCl_2$ and $Ca(OH)_2$, with dosages of 200, 500 and 500 p.p.m. respectively. The tetravalent salts were not effective because they hydrated either immediately upon being dissolved or a short time after dialysis commenced. A combination of $FeCl_3$ and $CaCl_2$ was not so effective as $CaCl_2$ alone. A summary of results obtained with the best chemicals after 8 hours' dialysis is shown in Table VII. The rate of O.C. value reduction corresponded with the hours of

TABLE VII.—*Effect of Various Chemicals to Anode Compartment*

Chemical Added	Cathode				Anode			
	Begin		End		Begin		End	
	pH	O.C.	pH	O.C.	pH	O.C.	pH	O.C.
$MgCl_2$	4.8	7,000	10.4	2,990	5.0	0	2.5	960
$CaCl_2$	4.8	7,000	11.0	2,800	—	0	1.9	1,005
$Ca(OH)_2$	4.8	7,000	11.2	3,225	9.2	0	2.3	780
None	4.8	7,000	10.4	2,660	7.1	0	2.7	910

dialysis, the greatest percentage reduction taking place during the first two hours. After 8 hours the O.C. reduction was very much alike for all chemicals. In no case was the liquor entirely free from suspended material, but it could be coagulated with $FeCl_3$ in dosages as low as 50 p.p.m. Fe. In dialysis without chemicals in the anode the liquor could not be easily coagulated. Sludge produced could be readily filtered without addition of chemicals. With additions of $Ca(OH)_2$ and $CaCl_2$ less and less chemical was required for coagulation with increasing time of dialysis. For instance, at the end of 2 hours' dialysis no coagulation could be obtained with less than 400 p.p.m. Fe, leaving a turbid liquor. After 4 hours' coagulation 100 p.p.m. Fe was required, with a dense sludge formed and a clear effluent. Removal of turbidity resulted in lowering of the O.C. values, amounting to approximately an additional 10 to 15 per cent.

Reducing Dilution and Anodic Water.—Many experiments were conducted to find methods whereby the amount of water used for dilution of the waste and for use of anodic liquor during dialysis could be reduced. Various combinations were tried. A brief summary of some of the results are shown in Table VIII. Operation with 500 p.p.m. $Ca(OH)_2$ in the anodic water produced a reduction in O.C. of 26.4 per cent, comparable to 25 to 27 per cent obtained consistently with other chemicals. The use of unneutralized anodic dialyzate gave an O.C. reduction of 21.4 per cent, as compared with the neutralized dialyzate of 27.4 per cent. The amount of lime required for neutralization was, however, 875 p.p.m. The use of cathodic effluent appeared best, but filtrability of all sludges produced was fairly poor, requiring from 8 to

TABLE VIII.—*Effect of Liquids Used in Anode and Cathode Compartments on Oxygen Consumed Reduction of Slop After 8 Hours Dialyses*

Liquids Used		Oxygen Consumed	
Anode	Cathode	Begin, P.p.m.	Reduction, Per Cent
Tap Water + $Ca(OH)_2$	Diluted Slop	14,000	26.4
Water + $Ca(OH)_2$	Diluted Slop + Anodic Dialyzate	14,650	21.4
Water + $Ca(OH)_2$	Diluted Slop + Neutralized Anodic Dialyzate	15,400	27.4
Cathodic Effluent	Diluted Slop	14,000	34.6
Neutralized Cathodic Effluent	Diluted Slop	14,000	33.5
Cathodic Effluent + $Ca(OH)_2$	Diluted Slop	14,000	32.2

over 10 minutes to produce dry cakes. Some turbidity was left in the liquor. It appears that the best method of operation would be to use water for dilution of the slop in the cathode compartment, discharging an equal volume of anodic dialyzate after each dialysis, using the cathodic effluent for the anode compartment for the next run. This would make possible a continuous process with constant charging and discharging, without increasing the volume of waste to be treated or requiring additional dilution water.

Effect of Temperature.—The distillery wastes studied are discharged at a temperature of 180–200° F. It might be assumed that higher temperatures would increase the rate of dialysis. As an illustration, results of two identical methods of treatment, except for temperature differences, are shown in Fig. 9. The liquids represented by Curve *A* were heated to 167–176° F. and those by Curve *B* were kept at room temperature. Surprisingly, the rate of 0.C. reduction was lower for the hot material, especially during the early stages of dialysis, whereas the O.C. of the anodic water increased at the elevated temperature during all stages of dialysis. It appears that no advantage is gained by electrodialysis of hot liquids. In fact, on account of the increase in conductivity in hot liquids, greater power consumption is required.

Comparison of Results

The flocculation of the colloidal material of slop dialyzed in the cathode compartment with tap water (with or without chemicals) in the surrounding anode compartments, can be attributed to two factors: (*a*) high concentration of OH ions (high pH) and (*b*) presence of cations. Tests showed that high pH values (10.5–11.5) alone were not sufficient to cause coagulation, but addition of divalent cations brought about immediate coagulation.

The fact that considerable migration of liquid took place to the cathode during dialysis indicates that the membranes used were negative or were negatively charged. Asbestos membranes have been found

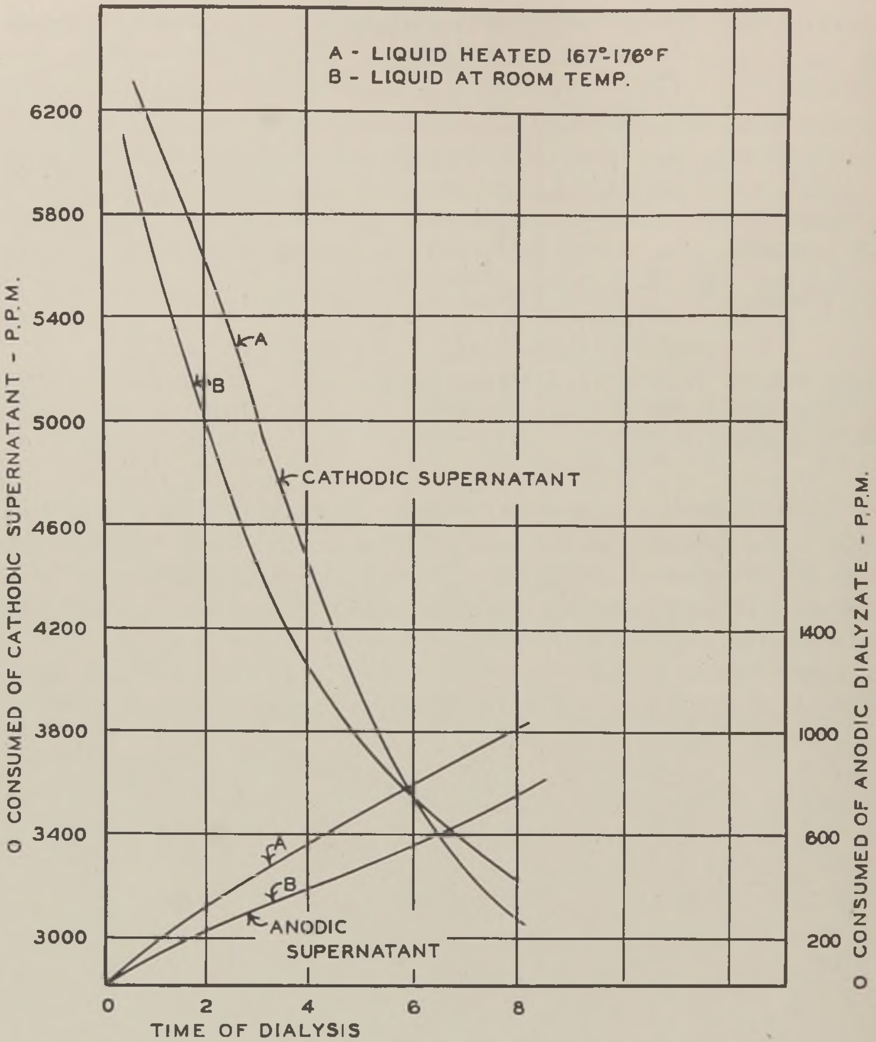


Fig. 9.—Effect of temperature on dialysis of diluted slop.

to act as a negative membrane (3), with the result that it is more permeable to cations and allows migration of liquid to the cathode. Our studies show very low rates of migration when the membranes were new or at the beginning of dialysis, but increasing rates when dialysis continued. This can be accounted for by the increase of negative charge on the membrane due to adsorption of a film of colloidal matter. In addition, as dialysis continues, the current density increases, causing a further increase in negative charge on the diaphragm.

When slop was dialyzed in the anode compartments, a movement of dialyzable organic acids to the anode took place. This material was relatively high in oxygen demand. The presence or the retaining of these organic acids may account for the impossibility of producing coagulation or flocculation of the colloids in the slop. Even with pH values as low as 2.0, coagulation could not be induced. The addition of high dosages of $FeCl_3$ does not result in coagulation. The action of these organic acids as "peptizing agents" may be the cause of prevention of coagulation.

It is of interest that the addition of $MgCl_2$, $MgSO_4$, $CaCl_2$ or $Ca(OH)_2$ to the anode water gave better results as far as coagulation was concerned than $FeCl_3$. This may be accounted for by the fact that Mg and Ca ions bringing about a higher pH when discharged in the cathode, whereas the Fe ion does not. Also, since there is reduction at the cathode, the ferric ion may be reduced to the ferrous ion, which has less value as a coagulant.

When slop is dialyzed with the material in both anode and cathode compartments, the anodic dialyzate is not readily coagulated, though the cathodic material can be flocculated. This again indicates that the presence of organic acids in the anodic material inhibits ready coagulation, while the movement of the dialyzable organic acids from the cathode makes the material amenable to coagulation. This same condition was noticed when anodic dialyzate was used for diluting the slop. Additional amounts of organic acids were introduced in the cathode slop, causing a longer dialysis period to transport these acids and resulting in a lower overall reduction of O.C. for the same time of dialysis. Neutralization of the acids with lime reduced the time required. The action of the lime may be twofold, namely, (1) increased number of bivalent cations available for coagulation and (2) stabilization of the organic compounds by hydrolysis.

Whereas with the Baltimore slop flocculation could be obtained without addition of chemicals to the anode water, with the Newark slop chemicals were required to obtain appreciable flocculation in 8 hours, indicating a higher content of acids and a lack of coagulating cations. The results obtained appear to indicate that the Mg and Ca ions are about equally effective for coagulation of the colloidal material. The Mg salts were, however, more effective in producing a filtrable sludge. Experiments with various types of lime on sewage coagulation and sludge dewatering, to be published shortly, are of particular interest in this respect.

The effect of dialysis on the amenability of the slop to coagulation with relatively small quantities of $FeCl_3$ indicates that dialysis should be continued only until sufficient organic acids have been removed from the cathode.

General Discussion

The use of electrodialysis as a means of treating distillery waste can be evaluated on the basis of (1) actual reduction in oxygen demand, (2) ability to cause coagulation of colloidal matter, (3) making the suspended solids amenable to chemical treatment, (4) producing a waste more adaptable for biological treatment, (5) limitation of electrodialysis, and (6) cost.

Results with asbestos membranes indicate that reduction in O.C. is primarily due to coagulation of colloidal material, brought about by a combination of high pH values and suitable coagulating cations. Cathodic dialysis for 3 to 4 hours is required to effect coagulation. Fur-

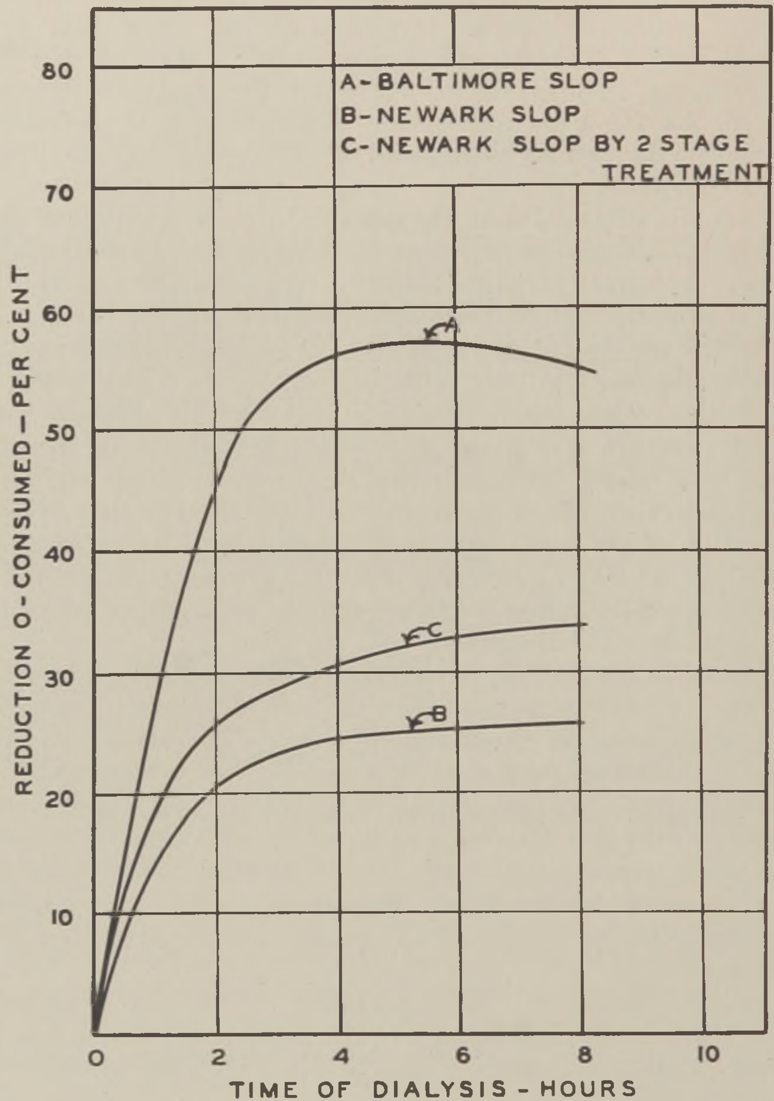


FIG. 10.—Overall reduction of O.C. by dialysis of diluted slop.

ther reduction of O.C. values of the slop are small, indicating that reduction of oxygen demand by oxidation or reduction is not appreciable. This is clearly shown when the overall O.C. reduction in the system is plotted against time (Fig. 10). After maximum coagulation is accomplished, the curves flatten out.

The removal of dialyzable organic acids appears to be mainly instrumental in making the slop more amenable to coagulation with chemicals.

The chemical dosage required decreases steadily, and after 4 hours only 20 per cent or less of the original chemicals are required. Exchange and migration of inorganic salts also takes place. In other types of wastes, inorganic salts may tend to hold colloidal material in suspension, consequently electrodialysis has practical importance for wastes containing dyes, color or finely divided organic suspended material.

The limitations of electrodialysis alone for distillery waste are that only colloidal material is removed and that it is only slightly effective in the oxidation of soluble organic matter. The degree of O.C. reduction can be anticipated by filtering the waste through a Seitz filter and determining the oxygen demand of the filtrate. In addition, about ⅕ to ¼ more of the total O.C. is removed when cathodic dialyzate is used for liquid in the anode compartment. This process can be considered a two-stage treatment. The question arises as to which factors are responsible for the further O.C. reduction. Possibilities are: oxidation at the anode by nascent oxygen discharges, chlorination by nascent chlorine (especially when salts such as $CaCl_2$ are used), and additional coagulation of colloidal matter due to lowering of pH values and migration of electrolytes. The last two factors seem possible from the behaviour of anodic material during dialysis, since there is a faint odor of chlorine at the anode and the material is readily coagulated when the pH drops. Oxidation is probably a minor factor.

From the foregoing considerations, it would appear that electrodialysis alone has a minor effect on the soluble organic material. However, the results indicate that dialysis followed by biological treatment produces more rapid and higher total O.C. reduction.

It is comparatively easy to reduce the O.C. value of the slop to 500–900 p.p.m. The material remaining resists markedly further oxidation. In this respect, it is of interest that treated material having 500–900 p.p.m. O.C. has a 5-day B.O.D. of only 200 to 395 p.p.m., or 40–44 per cent. It is clear, therefore, that the actual degree of purification and stabilization accomplished is higher than that recorded with other processes.

An attempt was made to determine the type and character of the organic material responsible for the residual chemical oxygen demand. Analyses of Seitz filtered slop containing 0.31 per cent total solids and 59.1 per cent ash with 667 p.p.m. O.C. and 254 B.O.D., indicated 22.1 p.p.m. total N and 1.6 p.p.m. NH_3, with no undecomposed proteins, reducing sugars or fats, and only traces of acetates, phosphates and chlorides. The indications are that the substances are mainly carbonaceous materials rather than nitrogenous in nature. The complexes are quite stable, similar to soil leachings or swamp waters.

Another factor of interest in connection with the biological treatment used was the foam formation occurring during aeration. At the beginning of aeration foaming was considerable, gradually decreasing. In an effort to determine the main reasons for the foaming, surface tension measurements of the anodic and cathodic dialyzates were made with diluted slop in the cathode. The results show a gradual reduction in surface tension of the anodic dialyzate as dialysis continued. The movement of organic acids to the anode was probably responsible for the decrease. The diluted slop in the cathodic compartment showed a gradual rise during the first 5 hours, followed by a rapid decrease. The decrease corresponded to the time when coagulation became effective. It appears that the colloidal matter in the presence of high concentration of dissolved salts or organic acids stabilized the air bubbles by coating. Further dialysis of the supernatant liquors of the anode and cathode showed similar behavior for a shorter time, with a more rapid rise and a greater drop in surface tension. It appears that some resinous material may also play a role.

The electrical energy required for dialysis was calculated for a number of tests. As an example, calculations on the basis of concentrated slop with an O.C. value of 50,000 p.p.m., electrodialyzed for 4 hours and using an average voltage of 17 volts and an average current of 0.82 amperes, the treatment of one gallon of slop by dialysis to reduce the O.C. by 55.4 per cent, required the expenditure of 1.06 KWH.

Conclusions

From the experimental laboratory work conducted and reported on the treatment of distillery waste from molasses fermentation, the following tentative conclusions are drawn:

1. The waste cannot be effectively treated by electrodialysis or by certain standard biological methods without dilution.
2. Electrodialysis alone results in an overall chemical oxygen demand reduction of about 55 per cent.
3. Electrodialysis in the cathode compartment effects coagulation of the colloidal material.
4. Electrodialysis does not reduce the O.C. of the soluble organic matter to an appreciable extent (7–10 per cent).
5. Electrodialysis in the cathode makes the slop more amenable to chemical coagulation, resulting in considerable saving of chemical required.
6. Addition of chemicals to the anode is effective in increasing the rate of coagulation, yielding a clear supernatant.
7. Dialysis produces a cathodic sludge readily filtrable without the aid of chemicals.
8. Electrodialysis followed by biological treatment resulted in a total O.C. reduction of the slop of 90 to 93 per cent after 8 hours' aeration.
9. After coagulation, little further reduction in O.C. is obtained by dialysis. It is not economical to continue dialysis treatment beyond coagulation, which occurs between 4 and 6 hours dialysis with asbestos membranes.
10. A stable residual soluble organic material remains after dialysis and biological treatment. A part of this soluble material can be oxidized chemically but not biologically even with prolonged treatment.

The B.O.D. of this material is about 40–44 per cent of the chemical oxygen demand.

11. Electrodialysis at higher temperatures produced poorer results than at room temperatures on account of the increased conductivity of the hotter material.

12. The ions causing dispersion of colloidal matter are removed to yield a dialyzate readily coagulated by chemicals. Treatment of industrial wastes by electrodialysis is most effective when large quantities of colloidal and small amounts of soluble organic materials are present.

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ANAEROBIC DIGESTION *

I. CORRECTION OF ERRORS DURING THE MEASUREMENT AND ANALYSIS OF THE GAS

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This article is designed to aid the anaerobic digestion experimenter in attaining greater accuracy in his gas measurements and analyses and to point out some helpful shortcuts. Errors commonly made in the measurement and analysis of gas are discussed and means of avoiding them or correcting them are pointed out. For example, ordinary gas analysis methods will indicate the presence of significant percentages of nitrogen in a gas composed of pure methane and carbon dioxide. This analytical error has contributed to the theory, now believed mistaken, that appreciable amounts of nitrogen gas are liberated by the anaerobic digestion of sewage sludge.

The data and conclusions presented here are the results of two and one-half years of experimental work at the Harvard Graduate School of Engineering. Much of the material is taken from parts of the author's doctor's thesis, entitled "Anaerobic Digestion of Human Excreta," written in December, 1938.

Gas Measurement

The proper design and assembly of a gas collecting and measuring apparatus is a prerequisite to accurate results. A highly recommended arrangement, the one used in most of the author's experiments, is sketched in Fig. 1. It consists of a four-liter Pyrex digestion bottle equipped with a sampling tube and a tube by which the evolved gases are brought over into a three-liter graduated cylinder to be collected and measured. As evolved gases accumulate the salt solution (30 gms. NaCl per 100 cc. solution) is forced out of the graduated cylinder into the leveling flask. When the cylinder becomes almost full it is disconnected from the bottle and a part of its contents analyzed before it is emptied and reconnected. While the cylinder is disconnected, gas is prevented from escaping by a clamp, and a small rubber stopper prevents air from mixing with the gases in the connecting tube. Careful wiring of all connections is essential. It is also well to seal the rubber stopper in the digestion bottle with hot paraffin after it has been wired down.

Readings may be made at any desired interval at atmospheric pressure by leveling the solution in the graduate and the flask. It is necessary to correct these measurements for the vapor pressure of the salt

* This is the first of a series of papers based on two years of research at the Harvard Graduate School of Engineering. The complete thesis of 220 pages was submitted for the doctor's degree in sanitary engineering, under the direction of Gordon M. Fair.

solution and for variations in temperature and atmospheric pressure. Corrections should also be made for the volume of gas in the digestion bottle, since it is similarly affected. To correct any reading to the

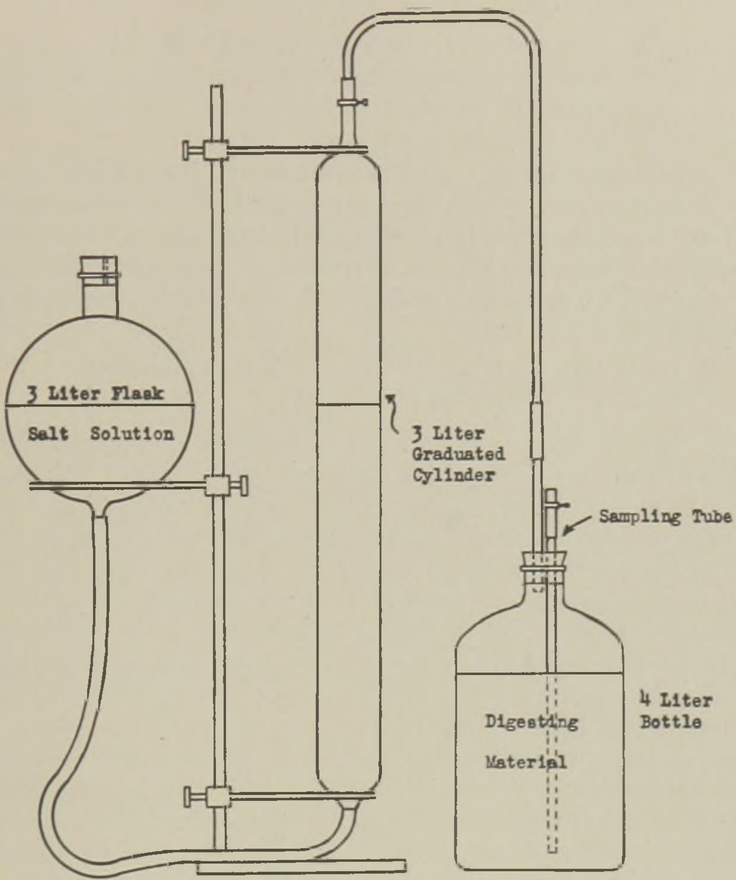

FIG. 1.—Digestion apparatus.

standard conditions of dry gas at 760 mm. pressure and 0° C. temperature, the following formula may be employed:

$$V \text{ std.} = (A + B) \times \frac{P_2 - \text{V.P.}}{760} \times \frac{273.1}{273.1 + T} - A \times \frac{(P_1 - \text{V.P.})}{760} \times \frac{273.1}{273.1 + T},$$

where

A = Volume of gas above the digesting material and in the connecting tube.
B = Volume of gas measured in the graduated cylinder.
V std. = Volume of dry gas at 760 mm. pressure and 0° C. temperature actually produced.
T = Temperature of the measured gas in degrees Centigrade.

V.P. = Vapor pressure of the salt solution at the temperature T.
P_1 = Atmospheric pressure when the graduated cylinder had no gas in it.
P_2 = Atmospheric pressure when the volume was measured.

Computations are reduced when the temperature is kept constant, but even then correction to standard conditions is very laborious. Further complications are added when the volume of gas above the digesting material, A, is varied during the experiment.

After a few months of experimental work, the author greatly reduced his computations by devising a special gas correction scale which was used during each reading of the gas production. The construction of this scale is shown in Fig. 2. By use of this correction scale the original complex formula was reduced to the following simple form:

$$V \text{ std.} = B \times \frac{273.1}{273.1 + 25} = 0.917 \times B.$$

As may be seen by inspection of the formula and Fig. 2, this scale corrects the volume of wet gas at atmospheric pressure and room temperature to an equivalent volume of dry gas at 760 mm. pressure and 25° C. temperature. This is accomplished by setting scale A at the observed atmospheric pressure and scale B at the observed temperature, and then raising or lowering the leveling flask, bringing slide A to the level of the solution in the flask and slide B to the level of the solution in the graduated cylinder. A reading now made of the gas in the graduated cylinder need only be multiplied by 0.917 to yield the volume under standard conditions.

The correction for atmospheric pressure can be made very easily by adding or subtracting a column of salt solution equivalent to the difference between the actual and standard atmospheric pressures. This equivalence is derived from the ratio of the densities of mercury and the salt solution, *i.e.,* 13.6 to 1.19. To correct the actual temperature to the chosen standard of 25° C., it is only necessary to find the equivalent pressure change. The standard of 25° C. was chosen because excessive pressure would have been needed to correct the temperature to 0° C. by use of this scale, and most of the author's experiments were conducted in a room held at 25° C. Since vapor pressure varies with the temperature, the correction for it can be combined with that for temperature alone. Thus, with 760 mm. as the zero mark, X, the distance in cm. to any temperature mark on the correction scale, is given by the following formula:

$$X = \frac{13.6}{1.19} \times \left(760 \times \left(1 - \frac{273.1 + T}{273.1 + 25} \right) - \text{V.P.}_T \right).$$

If all the experiments are to be performed at one temperature, as were the author's, the scale need correct for pressure only, since the temperature correction can be made by a single multiplication.

An error that becomes especially significant during the slow preliminary gas evolution is caused by the absorption of the oxygen of the air

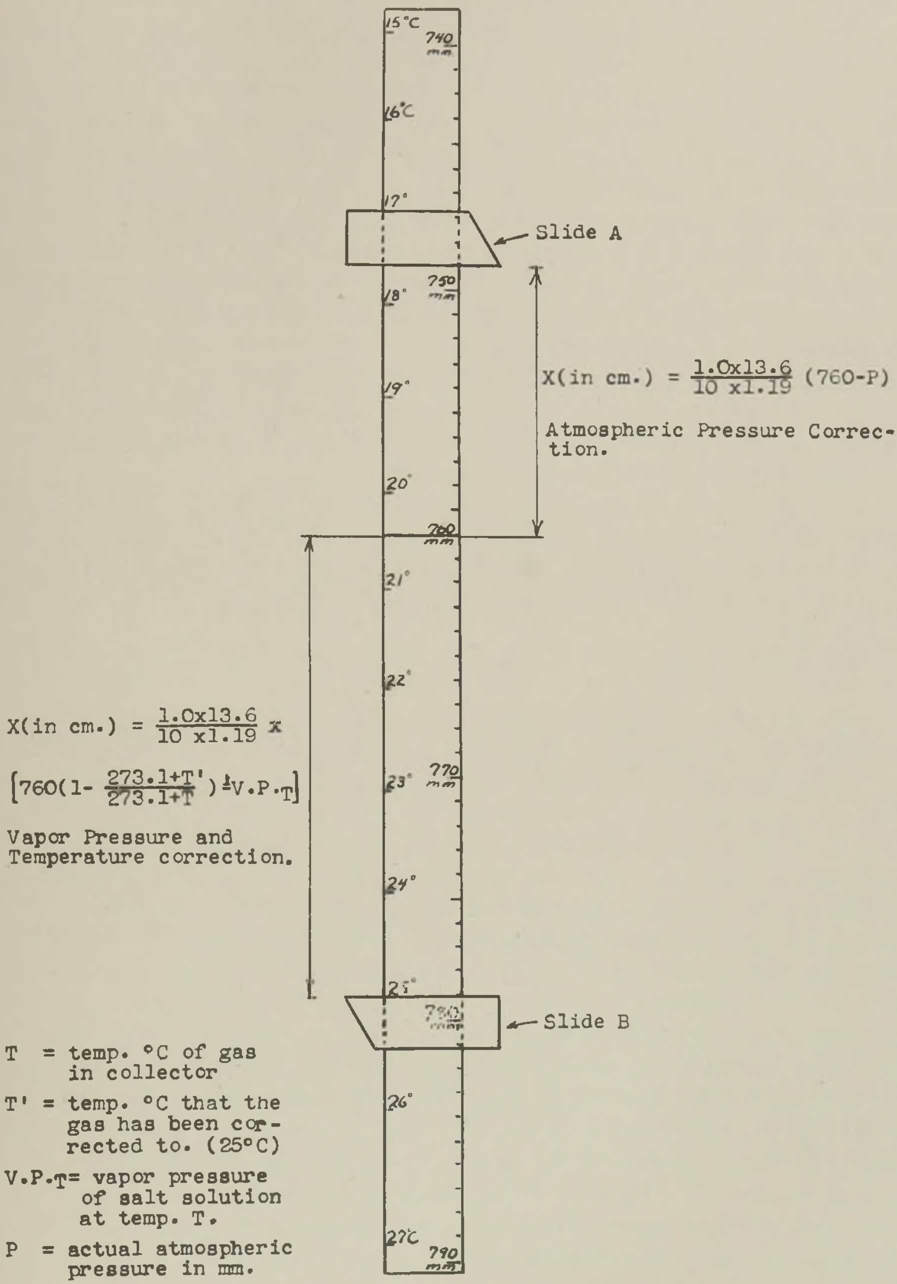

Fig. 2.—Gas correction scale.

originally present above the digesting sludge. The most convenient way of eliminating this error is to flush out the bottles with nitrogen gas at the beginning of the experiment. However, should this not be done, the volume of oxygen absorbed during any time interval can be computed from the gas volumes and the percentages of oxygen at the beginning and end of this interval.

Another error, also more significant during the slow evolution of gas, is the absorption of CO_2 by the salt solution in the graduated cylinder and its later liberation into the atmosphere from the leveling flask. The size of this error can be calculated by running CO_2 determinations on the salt solution in the graduate and the flask when the solution is about half in each, and assuming that the CO_2 lost is equal to the difference between the concentrations times the volume of the solution. In one of the slower experiments it was calculated that about 12.5 per cent of the CO_2 produced was lost in this way. From a ratio of the solubilities, the amount of CH_4 lost in this same way was calculated to be about 0.5 per cent of that present in the same experiment. Also 0.2 per cent of the N_2 and 0.1 per cent of the O_2 may have leaked into the cylinder from the atmosphere in this experiment. All these values become smaller as the rate of filling the graduate with gas increases, and, except for the CO_2, no correction need be made.

In some studies it is well to include the correction for the CO_2 made and held in the form of carbonates and bicarbonates. This can easily be done by determining the bicarbonates in the digesting mixture at the beginning and end of the experiment and converting the increase into free CO_2.

Gas Analysis

In all ordinary sewage sludge digestion experiments it can be assumed that the only gases present in appreciable quantities are CO_2, O_2, CH_4, H_2, and N_2. Under this assumption the standard procedure for gas analysis may be followed. In this procedure, the CO_2 is first absorbed in 33 per cent KOH solution, after which the O_2 is removed by bubbling the gas through alkaline pyrogallol. Next all but about 9 c.c. of the gas is discarded and the remainder is burned with about 100 c.c. of air in a slow-combustion pipette. The contraction is noted after burning and cooling, and again after a second absorption in the KOH pipette. The contraction due to the second CO_2 absorption indicates the amount of CH_4 present, while twice this contraction subtracted from that due to the combustion indicates the amount of H_2 present. The percentage of N_2 present is calculated by subtracting the sum of the other gases from 100 per cent. By burning 40 c.c. of the gas in about 90 c.c. of O_2, instead of 9 c.c. in 100 c.c of air, the probable error in the determination of CH_4 and H_2 can be reduced from about 2 per cent to less than 0.5 per cent. This increased accuracy is essential to the determination of the percentage of N_2 gas, and is also needed in the determination of the H_2.

Obvious errors in this standard procedure are the incomplete absorption of the CO_2 and O_2 and the incomplete burning of the CH_4. Incomplete absorption of CO_2 and O_2 can easily be checked by measuring, reabsorption, and remeasuring. To avoid incomplete combustion of the CH_4 and H_2, one should make sure of an ample supply of O_2, a bright red filament, and a sufficient number of slow passages of the gas over this filament. Also an error is sometimes made by not sufficiently cooling the gas after burning. Another error may be caused by inadequate flushing of the connecting tube and the apparatus with the gas to be analyzed.

In all gas analysis apparatus with manifolds certain appreciable and unavoidable errors are made in the determination of the percentages of N_2, O_2, H_2, and CH_4. A means of calculating these manifold errors and correcting them can easily be devised. Figure 3 shows a sketch of

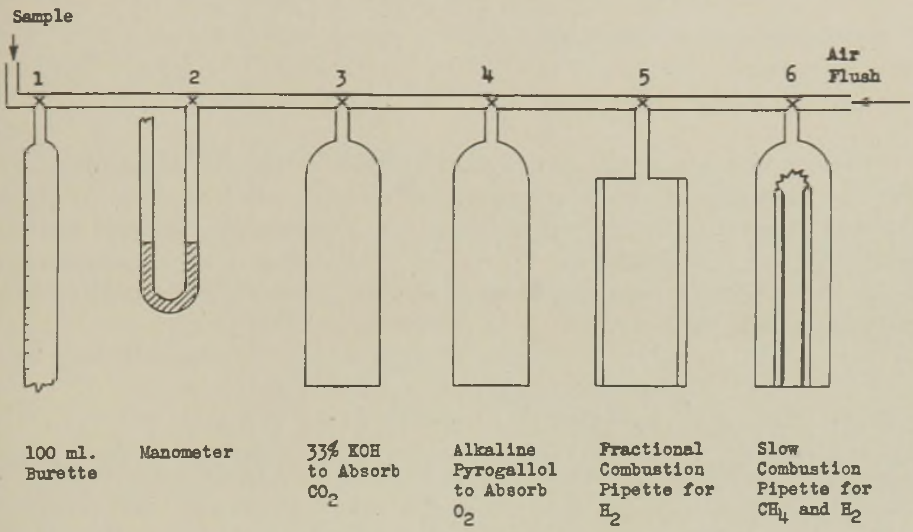

FIG. 3.—Sketch of gas analysis apparatus showing manifold errors.

the manifold analyzer used by the author. It is the kind most commonly employed by the anaerobic digestion research workers. The sketch shows a connection for an air flush which was connected to the compressed air line with a bleeder in the line to prevent excessive pressure in the apparatus.

In order to make corrections, the volume of the whole manifold was first found by filling it with CO_2 and then absorbing this, measuring the contraction. In the same way the volume between each pair of pipettes was found. The whole volume, V 1–6, was found to be 1.75 c.c., while each small volume, V 1–2, V 2–3, etc., was 0.35 c.c.

In the regular procedure 100 c.c. of gas was taken into the burette and the manifold was swept out with air (see Fig. 3). In absorbing the CO_2 and O_2 the air from the first three sections, V 1–4 $= 1.05$ c.c., is mixed with the sample, and $0.20 \times 1.05 = 0.20$ c.c of extra O_2 is absorbed in the O_2 pipette. The per cent of CO_2 is equal to the volume in c.c. of the CO_2 absorbed, as no manifold correction need be made. The correct per cent of oxygen may be expressed as follows:

Per cent O_2 = c.c. O_2 absorbed — (V 1–4)/5 = c.c. O_2 absorbed — 0.20 c.c. The volume of gas remaining after the CO_2 and O_2 have been removed, V_a, is reduced to V_b (about 40 c.c.) before it is burned. To this is added a volume, V_c, of O_2 to burn it (total V_d). The correction in the percent of N_2 present can then be calculated in the following manner:

$$N_2 \text{ error } = \frac{V_b}{V_a} \times \frac{4 \times (V\ 1\text{–}4)}{5} \times \frac{1}{V_b} = \frac{4 \times (V\ 1\text{–}4)}{5 \times V_a}, \quad \text{or}$$

$$N_2 \text{ error } = \frac{4 \times 1.05}{5 \times 60 \text{ to } 90} = 1.4 \text{ per cent to } 0.9 \text{ per cent too high,} \quad \text{or}$$

$$\text{Corrected per cent } N_2 = 100 - \left(\text{per cent } CO_2 + \text{per cent } O_2 + \text{per cent } CH_4 + \frac{4 \times (V\ 1\text{–}4)}{5 \times V_a} \right).$$

After combustion an error is introduced in the CO_2 absorption, giving too high a H_2 content, unless a lot of extra work is done to absorb the CO_2 from the manifold between the combustion pipette and the KOH pipette (V 3–6). If V_e is the contraction during combustion, V_f = the volume remaining, and V_g = the volume after final CO_2 absorption, then the

$$\text{c.c. } CO_2 \text{ trapped } = \frac{V_g}{V_f} \times (V\ 3\text{–}6).$$

Subtracting this from the regular equation for the c.c. of H_2 present, we get

$$3/2 \text{ of corrected c.c. } H_2 = V_e - 2V_g - \frac{2V_g}{V_f} \times (V\ 3\text{–}6),$$

$$= V_e - 2V_g \times \left(1 + \frac{(V\ 3\text{–}6)}{V_f} \right).$$

$$\text{Then the corrected per cent } H_2 = \frac{V_e - 2V_g \times \left(1 + \frac{(V\ 3\text{–}6)}{V_f}\right)}{3/2 \times V_d} \times \frac{V_a}{100}, \quad \text{or}$$

$$H_2 \text{ error } = \frac{2V_g \frac{(V\ 3\text{–}6)}{V_f} \times \frac{V_a}{100}}{3/2 \times V_d}$$

$$= \frac{2 \times (20 \text{ to } 40) \times \left(\frac{1.05}{90 \text{ to } 50} \right) \times \frac{60 \text{ to } 90}{100}}{3/2 \times 40}$$

$$= 0.5 \text{ per cent to } 2.5 \text{ per cent too high.}$$

The per cent methane calculated may be corrected by multiplying this calculated per cent by 100 and dividing by 100 minus the per cent error in the nitrogen and hydrogen, or

$$\text{Corrected per cent } CH_4 = \text{calculated per cent } CH_4 \times \frac{100}{100 - N_2 \text{ error} - H_2 \text{ error}}.$$

In the anaerobic digestion of sewage sludges and similar materials free from nitrates or nitrites, no N_2 gas, and either none or a very small percentage of H_2 gas is produced. Therefore methane and hydrogen can easily be grouped together as combustible gas. In the work of the author it was found that if the corrected percentage of methane were added to the corrected percentage of hydrogen and further correction made for the volumes of oxygen and nitrogen gases that had mixed in from the digestion bottle, this value would very closely approximate the percentage of combustible gas as calculated in the following formula:

$$\text{Corrected per cent of combustible gas} = \frac{\text{per cent } CH_4 + \text{per cent } H_2}{100 - \text{per cent } N_2 - \text{per cent } O_2} \times 100.$$

The percentages given in the formula need not be corrected percentages, as it seems that by its use the analytical errors are self-compensating and almost eliminate themselves.

Gas Analysis When N_2O and NO are Present

Anaerobic digestion of materials containing nitrites or nitrates may produce N_2O and NO gases. When these conditions exist it is necessary to alter the analysis to include a determination of the quantities of each of these nitrogen-containing gases. The standard method given by Dennis (1) can be used. This involves removing the CO_2 and O_2 by absorption, and then burning part of about 50 c.c. of H_2 in about 25 c.c. of the remaining gas. The nitrogenous gases unite with hydrogen as follows:

$$N_2O + H_2 \rightarrow N_2 + H_2O; \qquad 2 \text{ volumes} \rightarrow 1 \text{ volume.}$$

$$2NO + 2H_2 \rightarrow N_2 + 2H_2O; \qquad 4 \text{ volumes} \rightarrow 1 \text{ volume.}$$

The volumes of these two oxides of nitrogen (if they are the only ones present) may be calculated from the contraction. If V = the volume of the gas mixture without the hydrogen, and C = the contraction, then

$$V = \text{volume of } N_2O + \text{volume of NO, and}$$
$$C = \text{volume of } N_2O + 1.5 \times \text{volume of NO,}$$

from which it follows that the

$$\text{volume of NO} = 2 \times (C - V).$$

If nitrogen is also present another equation is needed. The H_2 used during combustion is therefore found by subtracting the volume remaining from the total volume added. The amount of H_2 remaining is determined by combustion with O_2. The volume relations then become:

$$V = \text{volume of } N_2O + \text{volume of } NO + \text{volume of } N_2\text{, and}$$
$$C = \text{volume of } N_2O + 1.5 \times \text{volume of } NO\text{,}$$
whence
$$\text{volume of } N_2O = 3 \times \text{volume of } H_2 - 2 + C\text{,}$$
$$\text{volume of } NO = 2 \times (C - \text{volume of } H_2)\text{, and}$$
$$\text{volume of } N_2 = V - \text{volume of } H_2\text{.}$$

Further complications present themselves in the possible presence in the original gas of CH_4 or H_2 or both. Fortunately, in the experiments performed by the author on the digestion of proteose peptone in the presence of $NaNO_3$, seeded with digested sludge, practically none of these gases were given off when the nitrogenous gases were evolved (see the second article in this series). If CH_4 or H_2 is proved to be present in significant quantities, the calculations necessary to determine the percentages of the various nitrogenous gases become very complex. It is a simple matter, however, to prove whether or not CH_4 or H_2 is present. The CH_4 present would be converted into CO_2 and H_2O upon burning with O_2. Absorption of the products of this combustion in the KOH pipette showed that in each case the author had present less than 0.3 per cent of CH_4.

The H_2 present in the gas could be determined by absorption of the excess O_2 after combustion, thus determining the amount of O_2 used. The amount of O_2 used is given by the following expression: volume of $O_2 = \frac{1}{2} \times$ volume of added H_2 remaining after the first combustion $+ 2 \times$ volume of CH_4, found $+ \frac{1}{2} \times$ volume of H_2 already present in the gas mixture. Since the third term proved to be zero in each of the author's experiments, indicating that no H_2 was present in the original gas, the complex adjustment of the N_2O and NO results was not necessary. The only correction needed was to subtract from the calculated percentage of N_2 the percentage of CH_4 found.

Summary

1. During studies on the anaerobic digestion of human excreta the ordinary technique for measuring and analyzing the evolved gases was improved.

2. A new correction scale is described, to be used during the reading of the volumes of the gases produced, and which automatically corrects for changes in atmospheric pressure, temperature, and vapor pressure.

3. Errors in measurement of the evolved gases are outlined and corrections are provided for them.

4. Avoidable errors made during the analysis of these gases are pointed out.

5. Unavoidable errors due to the manifold of the gas analyzer are shown to be appreciable, and are formulated and corrected.

6. A method of analysis is described for use when N_2O or NO gases may be present.

Acknowledgment

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THE OPERATOR'S CORNER

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

SEWER MAINTENANCE IN BOSTON *

By Robert P. Shea

Division Engineer, Boston Public Works Department

As this paper has to do with the maintenance of sewers in Boston I believe it will be helpful to review briefly some of the changes in area and topography that took place between 1822 and 1868, the former date being the year in which Boston became a city having at that time a population of about 43,000 people.

In 1822 the area of Boston was 783 acres forming a pear-shaped peninsula surrounded by the Charles River and Boston Harbor. It had three hills, Beacon Hill, Fort Hill and Copps Hill from which it derived the name "Trimountane." At the southerly end of the peninsula which lead to the mainland or the town of Roxbury was a narrow strip of land known as "Boston Neck," so narrow and low that at times parts of it were covered by water at high tide.

Material taken from Boston's three hills was used to reclaim land adjacent to what is the North Station and to create Atlantic Ave. Subsequent filling of the marshes on both sides of the Neck created the Back Bay and South End areas of Boston the material used for this purpose having been brought by rail.

As the result of the filling in of the marshes the land area of Boston increased, between 1822 and 1868, from its original 783 acres to 1800 acres. Additional territory was acquired by the development of East Boston and South Boston and by the annexation of Roxbury in 1863, Dorchester in 1870, West Roxbury and Brighton and Charlestown in 1874. Its bounds now embraced 27,251 acres or 42.6 square miles.

The first sewers were built in Boston previous to 1700 and from that time until Boston became a city in 1822 were privately owned and followed the shortest line to tide water.

The object of the sewers was the drainage of cellars and lands, sinks and roof water, the contents of cess-pools being excluded by law. Fecal matter was apparently admitted to the sewers after 1833.

The old parts of Boston, exclusive of the low lands in the Neck, were

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easy to sewer, the land being high, the sewers outletting at the shore line into tide water.

The reclaiming of land in the Neck, which had its beginning in 1848, was occasioned by a growing city in need of territory for expansion, and as the land was made available sewers and streets were laid out and constructed and the lots sold by the city. Building construction followed soon after.

The first land reclaimed in the Neck was filled too low to provide satisfactory drainage into tide water and subsequently the City was required to raise the buildings and regrade the land at a cost of about two million dollars. The regrading brought the streets up to elevation 18 and the basements of buildings and rear alleys to elev. 12, to which elevations the Back Bay area was filled, when that work was done.

As the filling progressed main sewers were built outletting into tide water. The filled land south of the Province Division of the N. Y., N. H. & H. R. R. had its principal sewer in Tremont and Dover St. with its outlet at Fort Point Channel, while the filled land north of the railroad had sewer outlets into the Charles River in Hereford St., Fairfield St., Dartmouth St. and Berkeley St.

The first sewers built in Boston were of wood, particularly in the filled areas where they were extended toward tide water as the filling progressed and laid directly on the soft mud. They have since been replaced with masonry structures.

Sewers in Old Boston and in the reclaimed land discharged into tide water. Drainage conditions in Old Boston were satisfactory, the land being high. But the same was not true for the reclaimed areas adjacent to the Neck even after regrading, as the discharge of sewage was subject to the height of the tide and consequently the sewage ponded until it reached a height above that of the tide. To provide storage space many of the sewers were made much larger than would otherwise be necessary, having tide gates at their ends to exclude the tide. The storage of sewage caused deposits in the sewers which gave off foul odors as did the discharge of sewage on to the tidal flats. These foul odors especially during hot weather enveloped the greater part of the city and gave rise to many protests by the public and warnings by the health authorities, who in one of their reports said in part, "Large territories have been at once and frequently enveloped in an atmosphere of stench so strong as to arouse the sleeping, terrify the weak and nauseate and exasperate everybody."

As the result of repeated warnings by the city and State Board of Health that the existing sewer system, especially the method of disposal, constituted an actual health menace, a Commission was appointed in 1875 to report on the then existing sewer system and to present a plan for outlets and main lines of sewers to serve the future wants of the city.

The report of the Commission contained a comprehensive statement of the defects in the existing system and the necessity of carrying the sewage for disposal to a point in tide water where it could do no harm. The report recommended for this purpose the construction of intercepting sewers along the margins of the city, one system on the north side of the Charles River to serve Cambridge, Somerville, Chelsea, Charlestown and East Boston, the other on the south side of the Charles River to serve Brookline, Roxbury and all of the city proper, which was to pick up the flow from the existing outlets and conduct it to pumping stations there to be raised about 35 feet into an outfall sewer leading from the pumping station to reservoirs where it was to be stored and discharged in the harbor during the first two hours of ebb tide.

The recommendations of the Commission met with general acceptance but one group who opposed it claimed that the slope of the proposed sewers would not produce sufficient velocity to prevent deposits, that solids in the sewage would clog the pumps, that during the summer season foul odors would emanate from the storage tanks and envelope the city and that during the winter it would become solid ice and result in a stoppage of the entire system. They added one other objection which I quote, "Such reservoirs and outlets might be reduced to ruins in any future day of hostilities, either foreign or domestic—should such hostilities ever occur the effect of which ruins would be the fatalities of the plague."

To date all their fears with the exception of the last one mentioned have been proven to be unfounded and I believe you will agree that our faith in America, our will to work, to fight and to suffer, if necessary, will make us ready to meet such a challenge should that time come.

Because of the opposition to the adoption of the commission's recommendations in its entirety the City Council adopted the recommendations for the construction of intercepting sewers on the south side of the Charles River that suffered most from the defects in the existing system and as a consequence surveys were started in 1876 and the construction of the intercepting sewers known as the Boston Main Drainage System was completed and put in operation in 1884.

After 58 years this same system, with minor changes, is functioning satisfactorily today and we might well pause for a moment to pay tribute to the memory of such men as City Engineer Joseph P. Davis and his successor Henry M. Wightman, to Eliot C. Clarke and all others who had a part in its building for their foresight, ingenuity, skill and craftsmanship, for they indeed builded well.

The limit of the drainage area assumed was the area between the Charles River, the Neponset River and Mother Brook which connected them, an area of 58 square miles. Of the 58 square miles, 46 were above elevation 40 and could be drained by gravity to Moon Island, and as this was intended there remained 12 square miles that would permanently remain tributary to the proposed intercepting sewers, but to take care of limited areas above grade 40 until such time as the high level sewers were built it was decided to assume 20 square miles tributary to the proposed system.

At the time that the intercepting sewer was being planned in 1876 the population of Boston was about 340,000. The population assumed for the 20 square miles being considered was 800,000 or 62½ persons per acre. The amount of sewage per person was 75 gallons per day, and the maximum rate of flow one and one-half times that amount or 139 c. f. s., to which was added 100 c. f. s. for about ¼ inch of storm water per 24 hours, resulting in a total flow at the pumping station of 239 c. f. s.

Lateral sewers picked up by the intercepter formerly discharged into tide water and continued to do so after the float regulator excluded from the intercepter other than the maximum dry weather flow and a small amount of storm water.

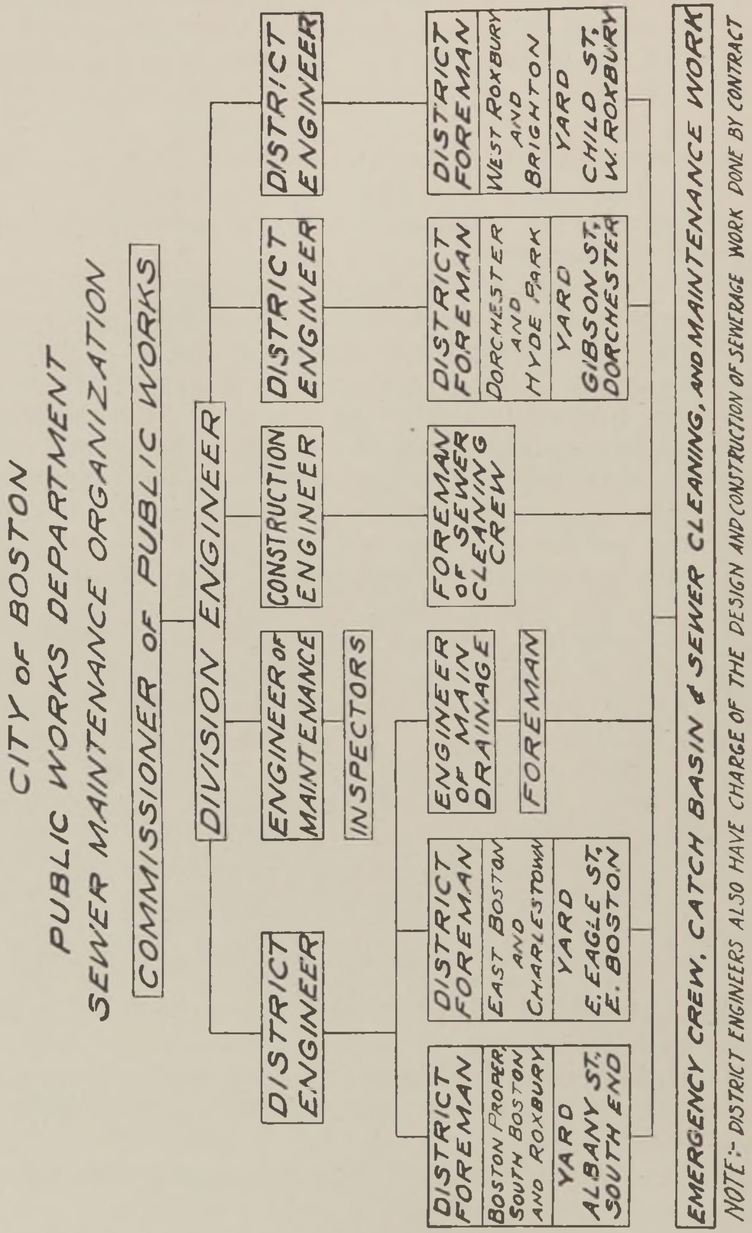
While this about completes permissible reference at this time to the Boston intercepter, it is necessary to make a brief reference to the North and South Metropolitan sewer systems which also drain Boston and for the use of which the city pays a large Metropolitan assessment.

As has been previously stated, the report of the Commission that resulted in the construction of the Boston intercepting sewer also recommended the construction of an intercepter on the north side and a high level sewer on the south side of the Charles River. Between 1895 and 1909 these and other sewers were built and have since been extended to drain in addition to Boston most cities and towns within a 10 mile radius of the State House. Charlestown and East Boston are served by the North Metropolitan system, part of the Back Bay, part of Roxbury, part of Dorchester, part of West Roxbury and the whole of Brighton and Hyde Park are served by the South Metropolitan system; most of the local sewers in Charlestown and East Boston are on the combined system which is true also for local sewers in downtown Boston. In general, all local sewers in the South Metropolitan system are on the separate system as required by law, and as far as Boston is concerned this requirement has been effectively complied with; which brings up the question that I am supposed to discuss, namely sewer maintenance.

Sewer maintenance may be divided into five classifications:

(1) Complaints received from the public and arising from defects in the sewer system either in sanitary sewers or surface drains or a defect in house drains, the latter by far being the more numerous.
(2) Cleaning of catch basins, of which Boston has about 22,500.
(3) Sewer cleaning.
(4) Maintenance of intercepting sewers, including tide gates, regulators and sumps.
(5) General repairs, consisting of repairing broken sewers, rebuilding tops of manholes and catch basins and the changing of loose grates, rings and covers.

The number of house connections in Boston is unknown. According to the Assessors' records of 1930 there were 116,000 buildings and as


CITY OF BOSTON
PUBLIC WORKS DEPARTMENT
SEWER MAINTENANCE ORGANIZATION
COMMISSIONER OF PUBLIC WORKS
DIVISION ENGINEER
DISTRICT ENGINEER
ENGINEER OF MAINTENANCE
INSPECTORS
CONSTRUCTION ENGINEER
DISTRICT ENGINEER
DISTRICT ENGINEER
DISTRICT FOREMAN
BOSTON PROPER, SOUTH BOSTON AND ROXBURY
YARD
ALBANY ST. SOUTH END
DISTRICT FOREMAN
EAST BOSTON AND CHARLESTOWN
YARD
E. EAGLE ST. E. BOSTON
ENGINEER OF MAIN DRAINAGE
FOREMAN
FOREMAN OF SEWER CLEANING CREW
DISTRICT FOREMAN
DORCHESTER AND HYDE PARK
YARD
GIBSON ST. DORCHESTER
DISTRICT FOREMAN
WEST ROXBURY AND BRIGHTON
YARD
CHILD ST. W. ROXBURY
EMERGENCY CREW, CATCH BASIN & SEWER CLEANING, AND MAINTENANCE WORK
NOTE:- DISTRICT ENGINEERS ALSO HAVE CHARGE OF THE DESIGN AND CONSTRUCTION OF SEWERAGE WORK DONE BY CONTRACT

many of the buildings have more than one sanitary connection, also because most of the buildings even in the combined districts have a separate roof water connection, it may be conservatively estimated that there are 200,000 house connections in Boston.

The maintenance force of the Sewer Division is about 123 men, the yearly payroll being about $190,000. The organization is shown on page 1318.

Because complaints have to do with the public and because they may result in claims for damages against the city they are given prompt attention.

The organization set up to do this consists of a maintenance engineer, in charge of the permit office, six inspectors or investigators who also supervise the laying or relaying of house drains and five emergency crews. The investigators are under the direction of the maintenance engineer, the emergency crews under the direction of four district foremen.

All complaints are received at, or referred to, the Permit Office where they are recorded on a complaint card and then telephoned to the district yard where the heading of a complaint report is made out and given to the emergency crew responding to the complaint. The complaint report is completed by the man in charge of the emergency crew and sent to the maintenance engineer where it is analyzed to determine if further action is necessary and then filed.

The purpose of the report is to establish the elapsed time between the time the complaint was received and answered, the cause and location of the trouble, that is, whether in the city sewer or the house drain (which is the property of and maintained by the abutter), and if any damage was claimed or observed.

If the complaint is located in the intown district or if the emergency crew is unable to locate or determine the cause of the trouble, and in all cases where damage of any kind has been done an inspector is sent to make an investigation, to review the emergency crew's report and submits his own written report especially in regard to the cause, nature and cost estimate of damage. These reports then become the basis of defense in the event a claim for damage is filed which work is handled by the Law Department.

The following notes refer to the kind and number of complaints received. In an average year we receive about 700 complaints of flooded catch basins (resulting in street flooding), and 625 sanitary sewer complaints, about 590 of which are due to stopped or defective house drains, 29 due to stopped sewers and 6 to broken sewers.

The greatest number of complaints received, in any one day, are during times of storm, from flooded catch basins, the cause being dirty or frozen basins, which are quickly relieved as soon as the trap is pulled. To prevent as far as possible street flooding from blocked basins, the entire labor force of the Sewer Division consisting of 80 men and a fleet of 25 trucks, is organized to patrol 700 miles of streets and 22,500 catch basins, which patrol is maintained for the duration of the storm. There have been times where a combination of melting snow and heavy rain required that the patrol be maintained on a 24-hour basis but such conditions are unusual.

Sanitary sewer complaints having to do with house drains may be divided into two classes, one where the house drain fails to function due either to a stoppage or to a defective drain with or without basement flooding, and two where there is no defect in the house drain but where the basement has flooded as the result of the drain cap having been taken off.

In regard to the former the city will attempt, without charge, to relieve the stoppage by rodding the drain, but in the event that it is necessary to blow the drain by water pressure a charge of $15 is made for this service. If there is reason to believe that the owner of the property is unable to pay the $15 charge, the work is done without charge as a health measure. In all cases the work is done at the owner's risk. As all house drains are privately owned all defective drains are repaired by the owner who engages a private contractor who must be a licensed drain layer.

In regard to the latter, that is where basements flood because the drain cap has been taken off and such cases are more numerous than one would suppose. Invariably the property is troubled from ground water because the foundation walls and floors are not waterproof and an easy way to get rid of accumulated water is to take off the drain cap, let the water run off and then replace the cap. This works o.k. during dry weather but the time comes when the cap is taken off during a storm, when the combined sewers are headed up, and because of the back flow it is impossible to replace the cap with the result that the basement continues to flood until the level of the water reaches that of the sewer in some cases to a depth of five feet.

There are all kinds of variations and combinations of causes for basement flooding but the point is that flooded basements, which in most cases have no direct relation to the sewer system, are the most troublesome source of complaints. Of course the solution is to comply with the building law by the installation of back-water valves, waterproofing basements and floors below grade 12 and by not taking off drain caps at any time, which is a violation of the law.

We have no trouble with modern buildings with waterproof basements that go several stories below the street surface. Our trouble comes from old buildings with low basements, that could be effectively waterproofed were it not for basement fixtures such as large refrigerators, compressors, elevators, etc., that make the cost of waterproofing prohibitive.

The emergency crews receive quite a few requests to recover articles (usually diamond rings) dropped into the toilet bowl but they are seldom recovered, although recently I witnessed the recovery of a

$1200 diamond ring that had been flushed down the hopper sixteen hours previously. Within the last 6 months we have had three requests to recover five diamond rings dropped into toilet bowls. Recently we recovered three days after they were lost a set of false teeth coughed into a toilet bowl by a man taken suddenly ill.

Cleaning Catch Basins

The cleaning of 22,500 catch basins is an important sewer maintenance activity. The work is done mostly by city forces, who clean about 6,000 basins a year supplemented by advertised contract that provides for cleaning about 1,200 basins a year.

A crew will clean about 8 basins a day, removing about 24 cu. yds. of material at a cost of $2.00 per cubic yard. The five machines clean about 6,000 basins a year. The price for contract cleaning is about $1.25 per cubic yard.

A cleaning machine receives hard usage and is constantly needing repairs. Many of the repairs are of a minor nature such as broken cables and bucket repairs but in the aggregate they account for a lot of lost time to the extent that one machine is always in the shop.

Each machine and bucket must be overhauled once a year at a cost of about $300 for the machine and $80 for a bucket. A new machine not including the truck on which it is mounted costs about $2,000 and a new bucket $350.

During hot weather we receive about fifty complaints of foul odors from basins, usually caused by discarded foodstuffs, fruit or vegetables that have been thrown into a basin, and occasionally by a dead dog or cat.

Sewer Cleaning

We use two methods to clean sewers: (1) The usual hand winch and bucket method, and (2) flexible rods and a rubber cup. There are about 1,250 miles of sanitary sewers and surface drains in Boston the sanitary sewers connected with either the Boston main drainage system or to the North or South Metropolitan system, the surface drains entering several local brooks which eventually outlet into tide water. Most of the sewers within the Boston main drainage system are combined sewers particularly in intown Boston or north of Massachusetts Avenue.

The common sewers are the most difficult to clean satisfactorily because being in the business district they receive large quantities of grease from food processing establishments and restaurants, which forms a heavy scum that is difficult to remove. You can pull a cleansing bucket back and forth through a sewer that has a sluggish flow from grease and while you will succeed in scraping off some of the grease from the wall of the pipe you cannot recover the grease or improve the appearance of the flow or its velocity. We get the best results by using a catch basin cleaning machine to remove floating grease from manholes and in this way recover a considerable quantity but it must be done regularly especially at siphon manholes. We try to prevent the entrance of grease into sewers by the regular inspection of grease traps which are required by the building law, but where a restaurant seating 500 people discharges its high temperature dish washing water in a sewer, it is bound to carry with it dissolved grease and food particles that congeal on the sides of the sewer and produce scum. In establishments where meat is cooked we require that the cooking water be allowed to cool and the grease skimmed off before the water is discharged into the sewer, but this does not prevent considerable quantities of grease from reaching the sewer.

While grease causes sluggish sewers it seldom causes a stopped sewer although it is the most common cause of stopped house drains.

The practice of disposing of garbage and ashes by flushing them down the toilet hopper frequently causes stopped sewers. This is a common practice in the crowded tenement districts. Whenever we clean a sewer in these districts we take out solid coal ashes mixed with everything that it is possible to dispose of by flushing it down the hopper.

As it has been said the usual method of cleaning sewers is by the use of hand winches and cleaning buckets, the contents of the bucket being hoisted to the street level and dumped into a truck for disposal. This method is of course slow and costly.

We also use an adjustable pipe scraper that will fit a pipe from 15 in. to 24 in. in diameter that is drawn through the sewer by a 1 in. rope by a power winch mounted on the sewer cleaning truck, the winch being driven by a power take-off from the truck motor. While the winch supplies the power to pull the scraper the cleaning principle is to wash the sand and gravel ahead of the scraper by water jets, the water pressure being supplied by flooding the upstream manhole, the jets being supplied by holes in a disk fitted to the scraper. This method is much faster than the hand winch and bucket and very satisfactory in sewers over 15 in. in diameter for the removal of heavy sand and gravel (Fig. 1).

For the past three years we have done considerable sewer cleaning with flexible rods and have had very good results. The equipment consists of ¼ in. diameter steel rods each 3 ft. long with a patented coupling on each end. About 300 ft. of rods are coupled together and wound on a reel when not in use. The rods are used to clean a sewer by threading them through a 1½ in. diameter guide pipe having a curved end and attaching a tool to the end of the rod where it protrudes at the curved end of the guide pipe. The guide pipe is then placed in a manhole with the curved end resting on the invert of the sewer and the upper end of the guide pipe just above the surface of the street. The rods are then pushed into the sewer until they strike an obstruction, at which time two hand ratchets are attached to the rods the first one about 15 ft. beyond the street surface end of the guide pipe and the second one 6 ft. beyond the first. The ratchets are attached to the rods at a rod coupling through holes provided for that purpose. Two men then work the ratchets to cause the rods to turn and drill through the obstruction until the rods reach the next manhole. The tools used for drilling consist of various forms of augers, their size depending on the size of the sewer.

Flexible rods using augers will drill through a sewer filled solid with hard material which would prompt one to say that this couldn't be done

FIG. 1.—Flushing truck and crew.

with wooden sewer rods, which is true, although we have had cases of sewer stoppages that the flexible rod wouldn't go through and where we were able to punch through the stoppage by jacking a ¾ in. diameter pipe although in this case it was found that the sewer was broken down as shown by the sample of material taken by the pipe, which leads to the conclusion that flexible rods will go through other than a broken sewer and that has been our experience.

With flexible rods the work can be done from the street surface which is a distinct advantage when the upstream manhole is flooded. With flexible rods we have freed a large number of stopped sewers and have drawn back the object causing the stoppage such as tree roots, pieces of plank, shovels, ice tongs, knives and forks picked up by the auger (Fig. 2).

Flexible rods are also used to clean sewers, the method being as follows: the rod is first passed through the sewer from the upstream to the downstream manhole in the same manner as described above, the guide pipe is then moved from the upstream to the downstream manhole and a rubber cup having small holes around its circumference, the size of the cup being smaller or the same size as the sewer, is attached to the upstream end of the flexible rod. The rods are then pulled from the downstream end until the cup has entered the sewer 3 or 4 feet where it is allowed to remain until the material to be removed is washed ahead of the cup by water under a head produced by flooding the upstream manhole from a fire hose. The washing allows the cup to advance and the sand and gravel is deposited in the downstream manhole where it is shoveled into buckets and hauled to the street surface for disposal. Sand and gravel entering the downstream manhole is retained there by

FIG. 2.—What sometimes clogs sewers.

inserting a sheet metal trap which allows the excess water to run off but retains the solids.

While this method of cleaning results in a cleaner sewer than that produced by a hand winch and buckets, the method is slow and hard work for the men employed. The flexible rod is also effective in freeing stopped catch basin connections.

The size of cups ranges from 6 to 18 in. in diameter.

The approximate cost of cleaning sewers by this method is 60c per foot.

General Maintenance

General maintenance work consists of repairing broken sewers, rebuilding catch basins and manholes, replacing worn out and noisy manhole frames and covers, repair of department buildings and work of a similar nature.

Maintenance of Intercepting Sewers

Maintenance of intercepting sewers, tide gates, sumps and regulators adjacent to both the Boston and Metropolitan systems is done by two crews of 5 men each and a foreman under the direction of an engineer. One crew patrols the city which is laid out in routes, there being a total of 200 stops on all routes where at each stop there is either a tide gate or a sump connection with either the Boston main drainage or the Metropolitan system. Their duty is to pull the covers, free any stoppage found, remove sticks from gates and report any repairs needed which is taken care of by the crew maintained for that purpose.

The engineer in charge of main drainage makes tests for oxygen deficiency in sewers where gas has been reported, also for explosive mixture resulting from gasoline or illuminating gas entering a sewer, and uses for this purpose a Davis combustible gas indicator and oxygen deficiency lamp.

Civilian Defense

The Commissioner of Public Works has organized the entire personnel of the Public Works Department for defense purposes, each division of the department to handle defense activities related to its normal activities.

The organization, the general details of which you are probably all familiar, consists first of a report center and second of crews and equipment to restore public services such as water, sewers and highways damaged by bombing or sabotage.

Each division has report centers manned 24 hours a day. For example at each sewer yard there is direct telephone service from adjacent warning centers established and maintained by the Boston Civil Defense Committee to notify the Sewer Division as to the location of so-called bombing incidents.

Each employee assigned to the Sewer Division for emergency work has been given an assignment card designating the location at which he is to report for duty in the event an air raid warning is sounded. A duplicate assignment card is on file in the yard to which the man is assigned.

The Sewer Division has attempted to compile a sewer division defense manual but the effort has not been altogether satisfactory.

Its purpose is to set forth the plan of organization and methods of construction to be followed covering several classes of sewer structures that may be damaged by bombing.

One conclusion that we have reached that is fairly definite, is that it is unwise to attempt to effect temporary repairs, in other words repairs must be of a permanent nature, and that such work is going to require about the same time and the materials and equipment as though it were an ordinary contract job.

Historical references to Boston and the Boston Main Drainage System taken from the memorial history of Boston and the report of Eliot C. Clark.

NEW YORK ASSOCIATION ENCOURAGES PLANT IMPROVEMENTS

The first Plant Improvement Contest sponsored by the New York State Sewage Works Association, conducted as part of the June Meeting of the Association at Albany, proved to be a real high-light of the meeting. This contest was recommended by the Gadget Committee, of which George W. Moore is Chairman, as a substitute for the usual Gadget Contest. The new activity was markedly successful in achieving its dual objective of encouraging operators to present worthwhile plant improvements and in bringing these projects to the attention of the Association's membership.

The entries were judged by a committee of qualified experts in sewage treatment works operation, in accordance with a scoring schedule which recognizes originality, ingenuity, clarity of presentation and general applicability of the improvement to other plants of similar type. The prize-winning entries are presented herewith, although some of the accompanying pictures have been omitted due to lack of available space.

First Award

An Odor Control Improvement

Entry of Glenn Pinckney

Superintendent, Webster, New York

Numerous odor complaints resulted in the first season of operation of the Webster plant, as the result of overlong retention periods in the settling compartment of the Imhoff tank. The sewage became septic, and upon aeration, when spread on the trickling filter, gases of decomposition caused quite serious complaints. An attempt to effect control by application of a bleaching powder solution to the raw sewage was not successful.

Definite improvement resulted, following the installation of chlorination equipment and, later, of a scrap iron tower (Fig. 1). Then, after experiments with the return of plant effluent to the raw sewage, it was found that the effectiveness of chlorine treatment was improved almost immediately. The recirculation made it possible to carry a chlorine residual at the trickling filters with only one-fourth or less of the chlorine dosage originally applied.

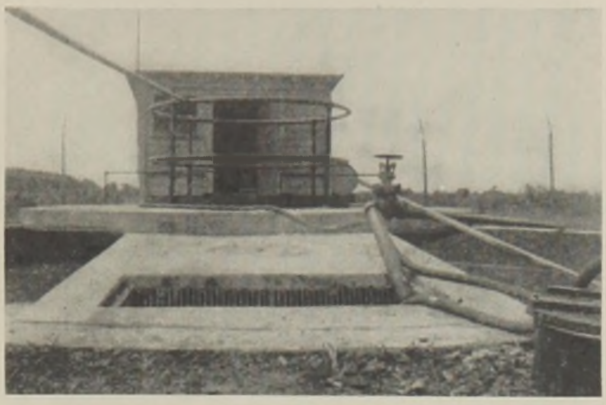


FIG. 1.—Showing Imhoff tank chlorinator building, circulation pipe discharge and scrap iron tower (lower right). Webster, New York.

Later, a special recirculation pump of fifty gallons per minute capacity was installed, and is operated from twelve to fifteen hours a day, depending upon the weather. The pump takes plant effluent from the final sedimentation tank and returns it to the inlet of the Imhoff tank. Automatic time control equipment obviates the need for manual attention (Fig. 2).

FIG. 2.—Close-up view of pump and time control switch. Webster, New York.

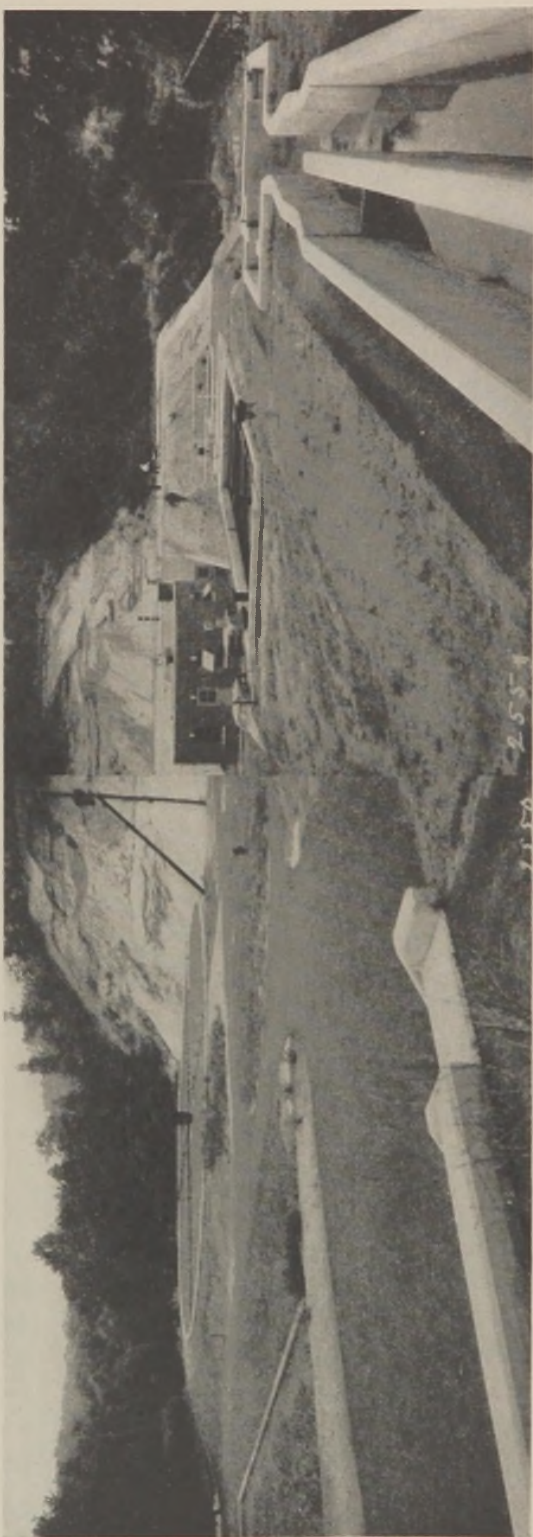


Fig. 3.—Rich's Dugway plant, Town of Brighton, N. Y. Note sand bank in background and adjacent to the trickling filter.

Second Award

A Grading and Drainage Improvement

Entry by Arnold Hale

Supt. of Sewers, Brighton, N. Y.

When the Rich's Dugway plant of the Town of Brighton was extended as a W.P.A. project in 1939, available funds were exhausted before final grading could be completed. This left exposed a large glacial sand bank which had been partially excavated to provide space for the new trickling filter. In the early months of operation of the new units, considerable difficulty was experienced at the trickling filter by windblown and sliding sand, and serious clogging of the filter stone and underdrain system was imminent (Fig. 3).

The regular operation and maintenance crew was employed in terracing and developing the sod covers shown in Fig. 4. The bank consists of eleven terraces of approximately 7 ft. each, all of which are shaped to drain the water to both ends so as to resist sand slides. They were then covered with 4 in. of sludge and seeded during the rainy season. In May, 1940, when the lower three terraces were mowed, the grass ranged up to 2 ft. in height and the slopes were well sodded and firm, showing no signs of sliding.

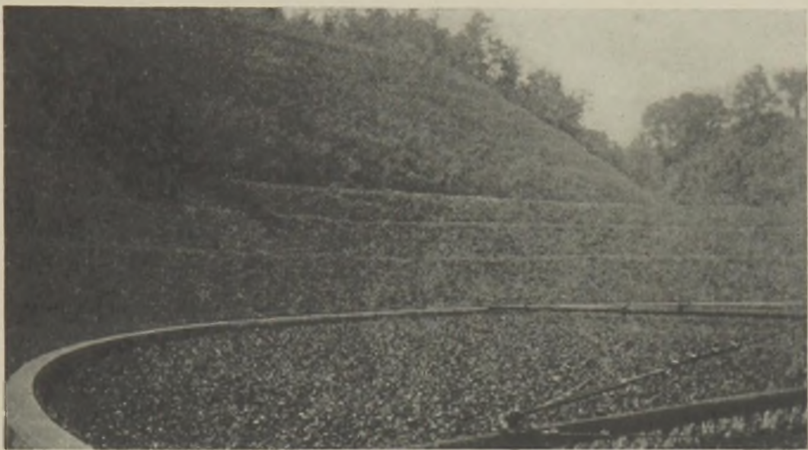


Fig. 4.—Sand bank shown in Fig. 3 after grading and seeding. Note terraces.

Third Award

A Supernatant Liquor Disposal Problem

Entry by E. A. Marshall

Chief Operator, Geneva, N. Y.

The Gulvin Park Sewage Treatment plant at Geneva was designed and constructed to handle 3.4 m.g.d. of sewage. A total pumping capacity of 12 m.g.d. and consisting of one 3 m.g.d., one 4 m.g.d. and one 5 m.g.d. unit was provided. The average daily flow of sewage to the plant has been 1.4 m.g.d., such a low flow that even the smallest of these pumps is caused to operate intermittently.

The plant piping is laid out in such fashion that, when fresh sludge is pumped to the digestion tanks, the supernatant flows through a 6-in. line connected to the raw sewage force main which discharges to the primary sedimentation tanks. The mixture of sewage and supernatant liquor is chlorinated while the pumps are in operation. When the pump stops, however, the digestion tank supernatant pockets in the force main and is discharged to the sedimentation tanks in a "slug" where it causes a thin black layer on the tank surface with septic action and odor, particularly during the summer months. Large doses of chlorine have been used to prevent these effects but the very concentrated mass of supernatant liquor will not respond to the chlorine treatment.

The objectionable condition at the primary tanks has been eliminated by means of ¾-in. water line which sprays water to the center of each tank just beyond the influent baffle, causing the supernatant to mix with the sewage in the tank and preventing the formation of the layer of scum. The method has been employed for the past four years and intermittent operation of the water jets have proven successful in controlling the supernatant solids, as well as other floating matter at the primary tanks.

Honorable Mention

An Imhoff Tank Dewatering and Repair Improvement

Entry by Clarence Kellogg

Supt. Water and Sewers, Mt. Norris, N. Y.

For several years our old covered Imhoff tank had given considerable trouble whenever we tried to draw off the sludge. We could draw approximately 30 cu. ft. of the sludge and the flow would stop and nothing would come out of the withdrawal pipe. We tried to clear the obstruction in the pipe by using the flushing ring, also by using a rod in the pipe and finally by hooking up a fire hose and flushing under pressure but no results were obtained. We then decided that about the only course left was to dewater the tank and locate the cause of the trouble.

Our next problem was to determine the most economical and labor-saving way that the dewatering process could be accomplished. After several methods were considered, it was decided that a winch of some description be secured and the sludge removed by bucketing. Several contracting firms who had pumping equipment for rent were contacted but none of them had pumps suitable for the purpose.

We secured an old hoist that had been removed from a garage service car, on which we mounted a ¾ h.p. electric motor and connected it with a flat belt drive, from the motor pulley to the larger pulley which attached to the driving shaft of the hoist. We then secured from a canning company an obsolete direct action machine clutch by which we could throw the drive shaft of the hoist into and out of gear. The reason for this was that when the clutch was placed in gear, it would wind the ⅜-in. cable which raised and lowered the bucket into the tank, onto the drum of the hoist and when it was out of gear, it would allow the drum of the hoist on which the cable was wound to run free, which would allow the bucket to fall back into the tank by its own weight.

Having no control of the bucket on its downward course was not at all satisfactory, so an old brake drum from an auto was placed on the winch drive shaft, and the brake shoe set in place so that the bucket could be controlled at all times. This arrangement was very satisfactory both when bucketing sludge from the tank and when letting men down into the tank and bringing them out.

Fig. 5.—Hoist arrangement for cleaning out Imhoff tank at Mt. Morris, N. Y.

After the hoisting equipment was assembled, it was taken to the roof of the Imhoff tank and placed on saw horses (Fig. 5) to provide sufficient room for the bucket to be raised high enough to be dumped into an inclined trough to carry the sludge over the side of the tank. Next the rear of the platform on which the winch was mounted was weighted with sand bags to overcome the weight of the buckets of sludge which were being raised. The end of the boom of the winch was then placed over the center vent of the Imhoff tank and was ready to go to work.

We next secured a 20-gallon galvanized ash can (Fig. 6) and reinforced it by placing ¼ by 2-in. band iron hoops around both the bottom and the top of the can. These hoops were then joined at top and bottom by pieces of the same size iron. A short piece of chain was attached to the top of the can to act as a bail and a ring placed on the bottom edge of the can to which a rope could be attached. The rope was run through a pulley wired to the boom of the winch about 18 inches from the end and when the top of the can was a few inches above the trough, which was constructed to carry away the sludge, the clutch was thrown out on the drive shaft, pressure applied to the brake drum and the bucket load of sludge was suspended so that when the rope that was attached to the bottom of the can was pulled, it raised the bottom of the can allowing the sludge to be dumped.

The plank sludge trough was pitched enough so that when a bucket of sludge was dumped into it, it readily flowed to the edge of the tank where another trough conveyed it to a temporary sludge bed which had been constructed for this purpose by a road grader.

FIG. 6.—Bucket used with hoist pictured in Fig. 5.

We could remove approximately 500 gallons of sludge per hour and when the sludge became quite heavy it was broken up by a stream of water from a fire hose which would thin it out so that bucketing could be again resumed. When the tank had been lowered to approximately 6 feet from the bottom, the sludge became so heavy that it would not flow into the bucket, so a swing chair was built to let a man down inside of the tank and shovel the sludge into the bucket. This last six feet was taken out entirely by shoveling—a much slower process than bucketing, as the men who went down into the tank (one at a time) could not remain in there to exceed one hour at a time, because of the heat of the tank and the rubber suits which the men wore. No temperature readings were taken but it was hot. When one man came out, another was ready to go down and do the shoveling.

When the tank was finally emptied, it was found that the bottom end of the withdrawal pipe was resting on the sloping bottom of the tank with not sufficient clearance between bottom of pipe and floor of tank to allow the sludge to flow into the draw-off pipe. We removed and shortened the draw-off pipe and when replacing it made sure that there was sufficient clearance between the bottom of the pipe and floor of the tank so that the sludge would flow readily. We have had no trouble since that time in drawing sludge from this tank. We also used our winch for removing the draw-off pipe from the tank and again in replacing it which saved a lot of hard work. It took a crew of five men approximately 22 working days to complete the dewatering and make the repairs to this tank.

BARK FROM THE DAILY LOG

By C. C. Larson

Guest Contributor, Chemist in Charge of Operation, Sewage Treatment Works, Springfield, Illinois

January 1—Rakes at screen house jammed during the night and raw sewage overflowed into front yard. A fine way to start the New Year out!

January 6—Finished overhauling the Clark gas engine and it ticks like a Swiss watch. Why don't we do this more often?

January 10—Checked the efficiency of the Worthington engine and found that it was producing 92 cu. ft. of air for each cu. ft. of gas consumed. We refer to this as our "Gas-Air Ratio" and 92 is a good figure for our engines.

January 13—Governor Green was inaugurated today with much pomp and ceremony and two jazz orchestras.

January 14—Installed automatic shut-off valve in the gas line to the Clark engine. This valve is actuated by the oil pressure system.

January 29—The gas production is splendid; over 100,000 cu. ft. per day. The sewage is quite thin and would hardly account for such a high rate. I suspect it is due to an accumulation of sludge and scum in the digesters which is working itself out. The large amount of gas burned of course tends to raise the temperature of the digesters and this in turn accelerates the gas production further. It may not be a strictly exothermic reaction but it is at least a case of "Nothing succeeds like success." We will of course pay for this once the paroxysm is over.

March 20—Removing the first sludge of the season from the drying beds.

March 31—The activated sludge is bulking badly. Sludge index is 275. It is a little early for this demon to rear its ugly head.

April 11—Took bids for a new 80 ft. primary settling tank and for constructing a concrete cover over our 95 ft. sludge storage tank. We are providing two mixing units and removable pipe grids for heating the digester.

May 26—Placed in service a new Link Belt mechanism for collecting and removing grits from one channel of our grit basins. The actual cost of removing our grits manually has never been excessive but this was a job that could always be put off in favor of something more pressing. As a result the grit basins have at times been neglected and the grits have been a source of annoyance through clogging of sludge pumps and filling up the digesters. We will have to move them now or they will cover us up!

June 5—Contractor began excavating with a drag line bucket for the new primary tank. Goodbye lawns and shrubbery.

June 9—Found a drive chain on one of the cross collectors of the secondary settling tanks broken. The hoppers are full of stale sludge and I hesitate to think what effect this will have on the mixed liquor when we pump it back into the aeration tanks but we have no alternative. Upon examination it was found that several rivet heads in the chain had corroded away permitting the rivets to slip out of the links. Strangely however in every case the corrosion occurred only on that end of the rivet which had been peened over in making up the chain and the normal rivet head was unaffected. Apparently in the process of hammering the end of the rivet the internal structure of the metal was so disturbed as to render it more susceptible to corrosion.

June 30—Activated sludge is bulking. Sludge Index—350.

July 3—We had a very heavy rain yesterday and as usual the activated sludge "got well" over night. I wonder what there is in rain water that affects such a rapid recovery? I have a feeling that it is something more than just a freshening effect.

July 8—Shipped three milk cans full of Gambusia affinis to former Governor Lowden at Oregon, Illinois, to assist in the eradication of mosquitoes on his "Sinnissippi" farm. We are blessed (?) with a stock of these tropical minnows in a lily pond at the treatment works. In 1934 we placed seventeen of the little fellows in our pond and now we have either five million or ten million. They are tropical in nature and have no right to survive in this climate, but they have thus far succeeded in violating all the rules. During the past few years we have made many shipments of these fish especially to the eastern states. Our main function is still that of treating sewage but at times this fishy sideline threatens to take command. For the benefit of anyone who might contemplate asking for some of these fish I beg to advise that we still have plenty of mosquitoes around our plant.

August 6—Dug up and cleaned the main gas line between the digestion tanks and the main building. It was rather badly clogged. Sewage gas has peculiar physical characteristics. It does not seem to flow through pipe lines as readily as does illuminating gas, especially through clogged lines.

September 15—Placed the new Dorr Si-feed primary settling tank in operation. This tank is 80 ft. in diameter and doubles our primary capacity and is a beauty. We have been forced to abuse our receiving stream somewhat during the period of construction because we were obliged to discharge the supernatant liquor from the digesters directly into the outfall sewer rather than into the raw sewage, which is the orthodox practice.

September 25—The Sludge Index on the activated sludge reached a new high today of 830. Needless to say it is bulking badly.

September 29—Digestion tank No. 3 is foaming. The pH is down to 6.0. We have been feeding this tank rather heavily so I suspect it is a case of a digestion tank having indigestion. We will starve the tank for a few days.

September 30—Many strange things come down to us through the sewers but I submit that just about the ultimate showed up today in the person of a live alligator about 18 inches long. He was pretty weary when we fished him out of the grit chamber but after a rather concentrated diet of grasshoppers (and he prefers them on the hoof) he is beginning to show some spunk. The accompanying picture is submitted by way of proof both as to his existence and to his spunk.

Fig. 1.—Chemist C. C. Larson exhibiting alligator taken from grit chamber at Springfield, Illinois

October 4—We had a cloudburst today. Nearly five inches of rain fell in as many hours. Flood water backed up through the outfall sewer and submerged the weir crests of the secondary settling tanks so we were obliged to shut the plant down for about six hours at the crest of the flood. Had to leave the same day to attend the Central States convention in Fort Wayne and the Federation meeting in New York City. This sort of thing always happens when you are planning to get away.

October 8—The analytical results for today constitute a splendid argument in defense of the much abused by-pass. Because of the recent heavy rainfall the sewers are thoroughly flushed out and the sewage is very dilute. The sample of raw sewage showed only 17 p.p.m. of solids whereas the plant effluent carried 19 p.p.m. of solids. In other words the river would have been better off if the by-pass had been open all day.

November 5—Gas production very low due to heavy rainfall and resulting dilute sewage.

November 26—Began filling newly covered digester with supernatant liquor from the other tanks in order to seed it.

December 1—As an experiment we have been operating through the month of November with a very low concentration of solids in the mixed liquor. The results were quite satisfactory but it should be remembered that the sewage was very weak.

Suspended solids in mixed liquor, 723 p.p.m.
Air applied, .43 cu. ft. per gallon.
B.O.D.—Raw sewage, 51 p.p.m.
B.O.D.—Plant effluent, 5 p.p.m.
Nitrates in plant effluent, 5.3 p.p.m.

December 7—Pearl Harbor.

December 8—Completed the erection of a new fence along the road in front of the treatment works. It's not a high fence but should serve as a warning to saboteurs and other dumb animals.

December 23—Started pumping a little raw sludge into the new digester. The motors on the stirring mechanisms are running hot.

December 25—Merry Christmas. No winter as yet.

December 30—Checked amperage going to stirring motors and found them to be overloaded by about 50 per cent. A short time later one of the flexible couplings between the motor and the stirring shaft failed.

PROGRESS IN PRIORITIES

The recent assignment of the administration of sanitation service priorities to the Bureau of Governmental Requirements of WPB gives indication that sewerage and sewage treatment functions may soon vacate their present place as the "ugly duckling" of Order P–46. This statement is not to be interpreted as a criticism of the Power Branch, which agency has heretofore served us faithfully insofar as was possible, but as a reflection against Order P–46, which applies primarily to electric power, gas and water utilities and the language of which demands an exceedingly active imagination on the part of those administering sewerage (sanitation) services. For an example of the "left-handed" terminology involved, one need read no further than the word "Producer" as used in the first paragraph of the order and begin to wonder as to "who's who."

A WPB release dated October 10 advises that public sanitation utilities "will remain under P–46 until the Bureau of Governmental Requirements gets out its own order" but are to "send all communications and applications to the Bureau instead of to the Power Branch." The secretarial office has been informed that the new order or an administrative letter pertaining thereto was in preparation late in October.

News of the above impending improvements in sewerage priority administration tends to overshadow the announcement of the October 10 amendments to P–46 which assign preference ratings of AA–5 to AA–2X to replace the ratings of A–5 to A–1-c assigned heretofore. It is understood that the new sewerage order will carry preference ratings of similar high rank.

Your Secretary takes this opportunity to acknowledge with thanks the cooperation of the 56 sewage works officials who returned the materials requirement questionnaires which were mailed out recently. The data compiled from the lists by G. J. Schroepfer, President-elect of the Federation, is proving of immeasurable value in determining the overall needs of the field. It may be of interest to report that Mr. Schroepfer estimates the steel and iron used annually in maintaining sewerage services would build 820, 28-ton tanks and that our annual requirements of rubber would provide 17,500 tires for Jeeps!

SEWAGE WORKS PRIORITIES *

Neil J. F. Van Steenberg
L. Malcolm Slaght
George J. Schroepfer
W. H. Wisely, *Presiding*

Chairman Wisely: I shall not waste time in explaining or describing the importance of this matter of material procurement. In presenting the priorities topic, we shall first have a discussion of the attitude of the War Production Board to sewerage services by Mr. Neil J. F. Van Steenberg of the Bureau of Governmental Requirements of WPB, then a discussion of the mechanics of sewage works priorities by Mr. L. Malcolm Slaght of the same Bureau, following which we shall hear from George J. Schroepfer, our Vice-President, regarding the materials requirements of the sewage works field as tentatively determined from the questionnaire survey recently made. Finally, the session will be opened to questions so that you may all have an opportunity to bring up your individual priorities problems at this time. Accordingly, I suggest that

* Symposium presented at Federation Conference on Wartime Sanitation, Cleveland, Ohio, October 23, 1942.

you begin to frame your questions so that you may receive the fullest advantage of the latter part of the session.

I take great pleasure in presenting Mr. Neil J. V. Van Steenberg of the Bureau of Governmental Requirements of WPB, Washington, D. C.

The Attitude of the War Production Board to Sewerage Services

Mr. Van Steenberg: I shall give you a brief summary of events up to this time without attempting to go into technicalities which may be better handled as opportunity is afforded for you to ask questions.

During 1941 we had been hoping for the best but were beginning to prepare for war. The O.P.M. in Washington had begun the gigantic task of mobilizing the nation. Its successor, the WPB, has carried on. The object was to forge the weapons to make our country invincible and to steel the nation for the greatest task of its existence, consequently, the War Production Board is now associated in most people's minds with guns, tanks, ships, ammunition, and so forth. We know, however, that the function of the Board extends further. It extends to that little-noticed area known as the home front—a very important one. Our cities must be kept healthy so that disease will not cripple our factories. Law and order must be kept, saboteurs must be apprehended. Hospitals must be readied for the grim harvest of war soon to come. Workers from our new plants must be housed as decently as possible.

To deal with these and similar problems, the Bureau of Governmental Requirements was set up within the War Production Board. Its chief is Maury Maverick and his function is to regulate the flow of material to the non-military aspects of the federal agencies, the state, municipal and county governments and to see that such functions that would normally subsist under this group of governmental agencies were performed with as little interruption as possible.

During the time that the War Production Board and its predecessor were learning their business and fumbling a little, shall we say, until we get down to business, priorities were issued without knowing where critical material could be obtained. The necessary ratings to obtain this and that material rose and rose, and after you had your project all set up and had priority for material, unless you got them right away, the rating was changed and the next day you had to start over. Necessary to the remedy for this situation was the knowledge of how much the various governmental agencies—the various consumers of goods—would need. In other words, there would be no change in priorities if you could estimate exactly how much steel was wanted for the Army, for the Navy, for water works, for sewers. It could be allocated then and you could go to the stockpile and get your share. One of the first jobs was to find out just exactly how much material was needed for these various branches.

Up to the present time, priority assistance has been extended to you by the Power Branch. You are undoubtedly familiar with the instrument as used, Preference Rating Order P–46. Those of you who have read the October 10 revision and amendment of this instrument will notice that wherever the sewerage system is mentioned, you are referred to the Bureau of Governmental Requirements and from now on you have your representative in Washington in that Bureau.

The Bureau of Governmental Requirements was swamped in the early days with federal works, with roads that had to be built, with defense housing, and so on, and it was not until recently that it was ready to take on the function that was specifically given it in the instrument setting it up, namely, the extension of the priority system to sewerage.

One of the first things I had to do, when I came on the job a couple of months ago, was to try to find out how much material was needed annually for the maintenance of sewers. In the course of this task, I happened to contact your Mr. Schroepfer at St. Paul and we discussed this matter in great detail. There had been some talk about sending out a questionnaire but this is exceedingly difficult in the War Production Board and I was very happy when Mr. Schroeper suggested that this organization conduct that survey. Your Secretary's office was very willing to cooperate with us in circulating this questionnaire which many of you have received and used in reporting your material requirements. Mr. Schroepfer is engaged in compiling and summarizing this material and will tell you something of his findings later. With this data before us, we shall be prepared to go before the Requirements Committee and ask for what you need—whether we get it or not is something else.

Estimates, at best, are unreliable these days. One unforeseen naval battle in the Pacific will upset the entire allocation system and we may have to deny you something which had been formerly allocated to your use. We are reasonably sure, however, that you may count on getting the material that you may need during the coming quarter.

There is no official ruling about who shall be favored in the event that we should find that there was not enough material to go around but considerable thought has been given this problem in the Governmental Requirements Bureau. At the top of the list in "musts" are water and sewers. They are first. Also, up near the top of the list, are such things as fire protection equipment and policing and then it ranges down to other governmental functions such as libraries, recreational facilities, etc., which probably will be allocated little or nothing. At least, these latter items will be the first cut off in case it becomes necessary.

I shall look forward to any of your questions which will enable me to discuss your specific problems better than I can in these general remarks.

Chairman Wisely: I should like to take this opportunity to acknowledge, with great appreciation, the cooperation of those of you who participated so willingly in connection with the materials requirement questionnaires referred to by Mr. Van Steenberg. The 56 per cent return on these questionnaires is unusually high for such an activity and I trust that this oral acknowledgment will suffice, in part, to take the place of the individual acknowledgments which I would have preferred to have given, but could not because of lack of time.

We shall next hear from Mr. L. Malcolm Slaght of the Governmental Requirements Bureau who will tell you how to get your priorities through and obtain delivery on the supplies and repair parts that you need.

Mechanics of Sewage Works Priorities

Mr. Slaght: When we were making plans for this meeting, Mr. Wisely advised me that you people would be primarily interested in maintenance, repair and operating supply priorities and only secondarily interested in the PD–200 project applications which pertain to new construction.

Most of my work for a long period of months has had to do with new construction and PD–200 applications. You may be interested to know that our current estimates on critical materials going into sewage works indicate that almost three times as much is going into new jobs as into maintenance, repairs and operating supplies. The proportion is about the same for water works.

I should like to comment briefly on your responsibility in the conservation of materials used in furnishing the public service you render. I certainly am not able to tell you how to conserve materials. We have a few men in the War Production Board who might know as much about it as many of you if they were on the job. There is nothing, gentlemen, that you can write on paper which will permit a man in Washington to decide whether your materials can be conserved or not as accurately as you can make the decision in your own office because you know all of the details of your problem or at least can obtain the information with little inconvenience. At the present time, the situation is that every pound of metal and other critical materials that you take out of the total production of this country to be used in sewage works, comes directly out of our Army, Navy and Maritime Commission production. The Army and Navy can use more planes, tanks and ships than the country can produce. We have factory facilities in a great many lines which are not working at capacity because we do not have the raw materials needed for them to produce at their maximum rates.

The primary problem at this time is in the conservation of metals, of which the first are, and this order is arbitrary, first, steel; second, copper and third, the ferro-alloying elements such as chromium and nickel. Every time you use something containing these metals, it means that you are using something the Army can use to fight the war and there is no limit to what the Army needs. The better we can equip our military forces, the faster we will win.

You have a major responsibility, with every other person in the nation, to exercise the most rigid form of conservation in buying materials for anything in the nature of a civilian activity. This is a matter for real measured judgment—a type of judgment that you must use if you are to do your full part in pushing this war to victory as soon as victory is humanly possible of achievement.

PD–200 (Project) Applications

Comparatively few of you, I expect, will be interested in project applications but those of you who are interested in them are, in all probability, intensely concerned. Preparation of a PD–200 application is mainly mechanical—making up the list of materials and breaking it down to show the exact quantities desired. The form requires you to list the equipment in detail and to state exactly what you are going to do in the way of construction. The principal part of the PD–200 application, however, is the statement of justification. You must not merely answer the questions in the front of the form in general fashion but should supplement these questions with additional remarks which will definitely establish the importance of your project in the war effort and the justification for building it now. Many of you have probably handled this form already and you may be sure that we realize that while we can review it in relatively short time, a great deal more time and labor has been expended in its preparation.

Unfortunately, I am afraid that people who have the most legitimate case for a project application usually give the least information. Too many times we receive applications attempting to justify a questionable project in which it is evident that the best engineering, legal and political talent in the municipality have collaborated to prove the project's value. Undoubtedly we have passed some of these projects. On the other hand, the man who has an open and shut case is usually inclined to feel that the situation is so evident that there should be no argument, then proceeds to assume that we in Washington are as familiar with the local details as he is himself. A poor application may entail correspondence, inspections and trips to and from Washington which can consume five months of time. A project application in proper form can run through the War Production Board, as we are presently set up, in forty-eight hours and I have put them through in twenty-four hours and even less on one or two occasions. You can count on forty-eight hour service if there is nothing wrong with the way your application is prepared. The primary job in connection with PD–200 applications is to tell the complete story by giving the entire background and justification for the proposed work.

Order P–46 contains a list of questions which should be answered in making requests for release from the restrictive provisions of the Order for small project applications. This is a very good list of questions and can be applied to the preparation of PD–200 applications just as well. If your application answers these questions with specific facts, with you bearing in mind that the official who reviews the application in Washington has probably never been in your city and knows nothing about it, the more likely your project is to be expedited.

Maintenance, Operation and Repairs—Order P–46

We shall now get down to the details of Order P–46 which places at your disposal automatic preference ratings for purchases necessary to maintenance, repair and operation of your facilities. These ratings are automatic and you are permitted to assign them yourself by either the endorsement contained in priorities regulation No. 3 or by the special endorsement that is indicated in P–46 itself. Where there is a large volume of purchasing, the endorsement is usually stamped on the order, provided with a number and signed—a very simple procedure.

You will notice that you are given the privilege of using the ratings assigned by P–46 at your own discretion. Although some of the early orders which were replaced by P–46 were probably the most abused of any issued by WPB, I have never heard such a reflection on Order P–46. Remember that you can do your bit in the conservation of critical materials by holding your purchases to a minimum, regardless of the fact that you have been favored with preference ratings of high rank.

When I arrived this morning I was under the impression that all of you would have had an opportunity to read Order P–46 as most recently amended on October 10. I now find that very few of you have received a copy of the Order in its new form and I shall direct your attention to three major changes which have been made. First, preference ratings assigned you have been advanced from A–2 to AA–5 for your ordinary needs and from A–1-c to AA–2X for emergency breakdown or to make reasonable advance provision against such breakdown, the latter rating to apply to not more than 30 per cent of your allowed dollar volume. Second, the amended Order makes it clear that public sanitation services have been placed under the jurisdiction of the Bureau of Governmental Requirements in WPB and directs that all reports and communications with reference to public sanitation be addressed to that Bureau. Third, the Order, as amended, contains a specific definition of what is meant by the inventory of a utility. There are also some other minor revisions and I think that you will find this Order to be in a most satisfactory form at this time.

AA–2X is probably a strange rating to you and to emphasize its value, I might say that ratings of this rank have been used in the past for such important purposes as the repairing of equipment that may have been damaged in combat. It is strictly an emergency rating and in being permitted to self-assign such a rating in this Order, I think you are getting more than any group has ever received so far from WPB. Although this rating will enable you to obtain delivery on almost anything you want to buy, up to the limit of 30 per cent of your total allowed purchases, let me remind you of your responsibility to conserve materials and to extend these ratings with discretion.

This Order also contains certain limitations which are designed to inform you of our policies. There are two general types of limitations, namely, quantitative and qualitative.

Quantitative limitations are dollar value limits which are based on the year 1940 as a base period or upon the comparable quarter of 1940, depending upon which you find to best meet your particular need. We appreciate that the increase in prices since 1940 has actually reduced, to some extent, the quantities of materials that you will be permitted to purchase today. The inventory limitation is also of the quantitative type. You must maintain your inventory of every class of material at a practicable working minimum and a report form is now in preparation which will enable you better to subdivide your inventories as to classes of material. Where reference is made in the Order to inventory restrictions for transmission and distribution facilities, you may consider that, so far as your industry is concerned, this will pertain to everything in your systems except sewage treatment works and pumping stations. There may be a question, in some cases, where small lift stations are involved. You must now operate with transmission and distribution material inventories at a level of only 60 per cent of what it was in 1940, thus making every pound of steel, iron, copper, brass and bronze in such inventories go as far as 1.67 pounds did before. Inventories of materials used in the maintenance, repair and operation of sewage treatment works and pumping stations may be held at 100 per cent of the 1940 level.

There is also a restriction on withdrawals from inventory—that is the material put into use—which restriction is identical to that on the inventory levels themselves, i.e., 60 per cent for items used on transmission and distribution (sewage collection) systems and 100 per cent for items used in sewage treatment and pumping works. If you are being called upon to furnish appreciably greater service than you were in 1940, there is provision made in the Order for any additional supplies which might be needed. You may increase both inventories and withdrawals in proportion to the increase in the total output of your system. For example, if you are furnishing 20 per cent more service now than you were in the corresponding quarter of 1940, your inventory withdrawals may be increased automatically by that 20 per cent without reference to WPB. Provision is also made for relief from the above quantitative limitations for unavoidable and emergency situations or to repair damage by act of public enemy, sabotage, explosion, fire, flood or other climatic conditions. Hence, if you encounter a real emergency which could not have been anticipated, you may proceed to use whatever you need because it is only reasonable that you should effect a remedy to such a situation as soon as possible. You must, however, make a report covering the entire matter in detail to the Washington office of WPB within a reasonable time after the emergency has passed.

Quantitative restrictions apply also to the minor property additions or expansions which are authorized under Order P–46. No such extension may be made under this Order unless it is specifically authorized by the Director-General for operations and second, unless it is less than 250 feet in length and is to serve a new building where the foundation was completed prior to July 1, 1942 or, finally, if it requires materials aggregating a dollar value of more than $1500 for underground construction and $500 for other types of construction. It is not permissible to break down a larger project into smaller portions in order to circumvent this last provision.

Now we come to the qualitative limitations of Order P–46 which I think may well be more important than the quantitative limitations. The qualitative limitations apply to critical materials which can be eliminated without serious loss of efficiency by substitution or design change. The Order specifically states that if you can substitute less critical materials or save materials by changing the design, then you must do it. It is, of course, impossible for us to police this particular provision in the Order and we are leaving compliance up to you. I urge you all to take advantage of every opportunity to use substitutes in place of the critical materials you may have used in the past.

The second qualitative limitation provides that all materials and supplies, including the small construction projects, allowed in the Order, shall be limited to those things necessary for minimum service standards. I do not believe that minimum service standards have ever been defined but you might consider it as one of the areas for judgment wherein you make provision for immediate satisfactory service without too much consideration for permanence. In other words, eliminate all of the elaborate features which may be highly desirable to the job but yet are not absolutely essential to your furnishing a service which will furnish the necessary protection to the public health.

I should also mention the provision made in Order P–46 which relates to construction intended for protection against sabotage, air raids or other acts of public enemy. The Order gives you a rating of AA–5 for materials to be used for these purposes but before you use that rating, you must submit a specific application for permission to use it and you must receive specific authorization from our Washington office before you can extend it. The fact that the Order states that you get the AA–5 rating does not mean much—the rating can be used only when you are given specific authorization. I think it is only fair for me to inform you that we are not in favor of any elaborate arrangements for protection against such things as sabotage and air raids and I will admit that this policy on the part of the War Production Board is largely due to my efforts. This general policy, implemented by Mr. Krug, who is head of all priorities, is that no materials will be provided for sabotage or air raid protection except for certain facilities absolutely vital to the war effort and only the barest minimum amounts will be provided in these cases, hence, if you are planning to fence in and light your property to discourage saboteurs, you had better count on using a wood fence and painted wood reflectors for the lights because it is not likely that you will be given priority ratings which will enable you to purchase woven wire fence or large reflector beacons.

May I again direct your attention to the list of questions contained in Order P–46 which must be answered when you make application to the Bureau of Governmental Requirements for permission to exceed any of the limitations of the Order. These questions must be answered completely before any ratings of special rank will be permitted and these same questions should be kept well in mind in the preparation of other applications such as PD–200 and PD–1A.

Proper Use of PD–1A and PD–200 Applications

When you find it necessary to make an extension of service or to undertake construction which will exceed the limits allowed in Order P–46, you can submit a PD–200 form or PD–1A form—but you must be certain to submit the proper one. We have experienced a number of unfortunate situations in this connection. Form PD–1A should be used only where your project involves a total cost, including labor, of less than $2500 or where not more than five items of critical material are required. In all other cases, the PD–200 form must be used.*

Chairman Wisely: Thank you, Mr. Slaght.

We shall hear, at this time, from George J. Schroepfer who consented to undertake the task of compiling and summarizing the materials requirement questionnaires which were recently obtained from fifty-six sewage treatment plants by the Federation. Mr. Schroepfer will present the tentative basic requirements of materials by the sewage works field as determined from his study of that data.

Sewage Works Materials Requirements

Mr. Schroepfer: Early in September we conducted a sort of Gallup poll for the purpose of estimating the quantities of the various critical materials which are used annually in maintaining sewerage and sewage treatment services in the United States.

Questionnaires were mailed to 100 municipalities from which fifty-six returns were received—a very good percentage. The municipalities included in these returns represent about twenty-five per cent of the population of the United States which is served by sewage treatment facilities.

A total of 140 questions was asked in the questionnaire and I know that it was difficult for you to fill them out. However, if you thought you had a difficult time, you should have had my assignment to go over fifty-six of them in one week in order to develop something for the use of WPB in connection with steel allocations.

Table I is a tentative summary indicating the annual usage of certain critical materials in sewage works during the year 1940. You will note that the quantities, as reported, were reduced to units per thousand population served and then expanded to give an approximation of the quantities used in the entire nation.

As you study the table, you may be interested to note that the steel and iron used in sewage works in one year's time amounts to enough to build a 25,000 ton battleship and that the 400,000 pounds of rubber used is sufficient to manufacture about 20,000 tires. This will give you some idea of the magnitude of our requirements and will show the need for improvising on our part in the operation of sewerage facilities and for further improvising on the improvisations as time goes on. I think

* WPB Administrative Letter No. 7, dated October 9, will be found a helpful reference in filing PD–1A and PD–200 forms. A limited supply of these instructions is available at the Federation Secretarial office, Box 18, Urbana, Illinois and copies will be furnished on request.

TABLE 1.—*Federation of Sewage Works Associations*

Tentative Summary of Questionnaires on Use of Some Critical Materials in Operation and Maintenance of Sewer Systems and Sewage Treatment Works in 1940

Item	Unit	Quantity	Population Served	Quantity per 1000 Population	Approximate National Total*
(A) Sewer Collection Systems					
1. Castings, Pipe and Other	Lb.	2,271,697	4,793,008	473.0	37,800,000
2. Steel and Iron	Lb.	162,240	5,202,554	31.2	2,500,000
3. Rubber Products	Lb.	25,589	5,269,630	4.85	387,000
(B) Sewage Treatment Works					
1. Ferrous Metals	Lb.	1,084,895	9,481,679	115.0	5,700,000
2. Non-Ferrous Metals					
Brass, Bronze and Copper	Lb.	28,149	9,485,679	2.95	148,000
Lead	Lb.	5,823	6,165,797	.95	47,500
Aluminum	Lb.	4,205	5,736,179	.73	36,500
3. Paints, Except Aluminum	Gal.	5,933	7,416,796	.80	40,000
4. Chlorine	Lb.	5,301,058	9,564,008	555.0	27,800,000
5. Fuel Oil	Gal.	937,000	9,583,083	97.7	4,900,000
6. Gasoline	Gal.	129,881	9,583,083	13.5	670,000
7. Rubber	Lb.	26,743	9,592,750	2.78	139,000

* Sewer System Quantities Based on 80,000,000 Population Served in 1942.
Sewage Treatment Quantities Based on 50,000,000 Population Served in 1942.

we should all be grateful to those who furnished the information submitted in the questionnaires because without their cooperation this project would not have been possible.

CHAIRMAN WISELY: We have on hand a liberal supply of the recent Administrative Letter No. 7 issued by WPB which will be helpful to any of you in handling PD–200, PD–1A and other special application forms for preference ratings. We also have a few copies of Order P–46 as amended October 10, which will be available, as long as they last, to anyone requesting them.

We shall now open the meeting to questions and answers. I am sure that all of you who have operated or built anything in connection with sewage plants in the past year or so have had some sort of priority trouble. Let us have them now.

H. T. RUDGAL (*Kenosha, Wisconsin*): Referring to the limitations for ordering materials, what basis should be applied to a plant which started operation in 1940 and had no previous purchase record?

CHAIRMAN WISELY: Certainly in a case of that kind it should be permissible to use a little common sense and use the first full year of operation data that became available. I shall ask Mr. Slaght to comment further.

MR. SLAGHT: While most of our maintenance and repair orders and all other types of orders have a specific provision covering that contingency, I am sure it is not covered in P–46. Mr. Wisely's answer certainly is correct—it will be satisfactory for you to use your first full year of operation as a base. If the first full year of operation is not indicative of your needs, and it may not be when you have just started a new plant, I think the solution is for you to write a letter to the Bureau of Governmental Requirements, War Production Board, giving any figures you may have for the first quarter or year and explaining in detail your estimates of what you think you may need. It will then be possible for us to furnish you with an authorization to use a suitable basis for your procedure under P–46.

L. H. Enslow: Mr. Slaght, will it not be possible from the work the Federation has done in making an inventory survey, to arrive at certain figures expressed in quantities per thousand population that would be a useful guide in determining what an inventory should have been in 1940? I suggest that as an idea for determining some workable basis.

Mr. Slaght: Since sewage disposal systems vary in type rather widely, I think that your suggestion would be impractical. I believe it would be possible for the Federation to develop something for your use in the nature of goal figures. By comparing your own limitations under P–46 with these goal figures, you may find that your requirements are considerably in excess of them, indicating how intensively you might go about material conservation in operating your facilities. The practicability of applying average data, in view of the variation in the size of municipalities and methods of handling sewerage problems, is one that I should not attempt to discuss at the moment.

Paul D. Cook (*Painesville, Ohio*): Referring to paragraph E–2 of P–46, which refers to the application of a housing project rating to utility construction, did Mr. Slaght state that it was wise to answer the questions in P–46, as well as those in PD–200 Did he refer to both of those lists of questions?

Mr. Slaght: Yes, the PD–200 form should be filled out completely but you should be certain that the list of questions contained in P–46 is also covered. You can make decisions of that sort entirely on your own if you will place yourself in our position. We are trying to make a decision on the basis of information you furnish—what we want is a story which will permit us to make a decision. If you leave out this or that question, it is not so important, provided that you answer every question which applies particularly to your situation. Do not hesitate to write a page or two on a question which appears to bear upon a major point in your case.

Mr. Cook: One further, minor question. Do the district offices of WPB have authority to grant the use of preference ratings or must such authorizations come through Washington?

Mr. Slaght: That is an authority which has not yet been vested in the district offices. Our district and regional offices can frequently be of very considerable service to you, but mainly in an advisory capacity.

Morris M. Cohn: Do the requirements of P–46 apply to refuse incinerators?

Mr. Slaght: The answer to your question is categorically yes.

Mr. Cohn: We have a refuse incinerator equipped with a 20 h.p. motor. This motor burned out and was repaired under an emergency order. We have a second 20 h.p. motor which appears to be in such physical condition that it, too, may go, leaving us with the problem of trying to obtain a complete spare motor for that purpose. We have been warned that it would be difficult to get a proper priority rating to purchase such a motor because of the shortage of copper. Can we apply an AA–2X immediately to a purchase order, Mr. Slaght?

Mr. Slaght: Yes, you can apply the AA–2X right now and probably get the motor on an AA–5 if you are a good shopper.

George J. Schroepfer: I should like to have a definite answer to this one question. Where we have a special problem that must be taken up in Washington, is it taken for granted that we write specifically to the Bureau of Governmental Requirements?

Chairman Wisely: I think it has been definitely stated that all sewage priority matters will be handled through the Bureau of Governmental Requirements rather than the Power Branch as has been the case heretofore. This is one of the most important facts brought to us today.

W. R. Gelston (*Quincy, Illinois*): I had a letter within the past week from the War Production Board giving an interpretation to the effect that where a water and sewage system are under joint management, all questions pertaining to water or sewage should continue to apply through the Power Branch. Does your statement supersede that letter?

Mr. Slaght: For the moment, water matters are handled in the Power Branch and sewage matters in the Bureau of Governmental Requirements. We believe that arrangements have been made so that you will not encounter any great confusion if you write a proper reference on your letter. Most of the problems you will have will be specifically in connection with either water or sewage. If you have a problem which includes both, address it to either agency and you will get an answer because we check back and forth in our work pretty closely.

Mr. John H. Brooks, Jr. (*Worcester, Massachusetts*): There has been some misunderstanding in my city as to the meaning of the $1500 limitation as applied to underground construction such as sewers. Does the $1500 limitation in P–46 apply only to critical materials or does it include other types of materials such as pipe, sand and cement which are the main items?

Mr. Slaght: The limitation includes all materials. In many of our construction limitation orders the total construction cost, including labor and engineering, will govern. This Order says "material" and does not refer to "critical material." I might add that you will get a little more consideration for construction projects which do not involve iron, steel and copper than one which does but you must keep in mind that there is a very considerable shortage of construction machinery and labor which makes it necessary to exercise control over all construction.

Morris M. Cohn: Mr. Slaght recommended that we soft pedal expenditures for protective measures in sewage treatment works. He gave examples which referred more to sabotage control than to air raid damage. Do I take it, Mr. Slaght, that the paragraph on air raid protection also includes protection against sabotage?

MR. SLAGHT: Yes, sir, it does. My remarks on that were statements of my own rather firm opinions, as well as of WPB policies.

WILLIAM A. ALLEN (*Pasadena, California*): I would like to ask in regard to the 30 per cent limitation on the application of the AA–2X emergency rating in any quarter. If you have a repair job that requires in excess of the 30 per cent allowed, must permission be obtained from Washington before the AA–2X rating can be used?

MR. SLAGHT: If you exceed the limit, you must definitely have authorization and that authorization must be obtained by means of a PD–1A form. The PD–1A form of application should be used where such higher ratings are sought, as well as in connection with project applications.

MR. ALLEN: Could that permission be obtained by telephone or telegram if it is urgent?

MR. SLAGHT: Yes, and it could be taken care of in your local office in San Francisco or in Los Angeles. We hope to be able to handle such things in a matter of two or three hours where there is a demand for real urgency.

You people have an odd job on the west coast in view of the fact that rating requirements at the moment are generally higher there than in the rest of the country. We are hopeful that the situation will not prevail for many more weeks. I would strongly suggest that you purchase materials from the east and middle west in order to get them at a lower priority rating, even though some additional expense may be required. What you purchase from available stocks on the west coast at this time leaves that much less for immediate military requirements in that region.

CHAIRMAN WISELY: We must now suspend this discussion. I say suspend because any further questions, and I am sure that there are others, can be handled in the "Priorities Clinic" across the corridor.

In concluding this session on priorities, I should like to thank Mr. Van Steenberg, Mr. Slaght and Mr. Schroepfer in behalf of the Federation.

Editorial

THE JOURNAL AND THE OPERATOR

The SEWAGE WORKS JOURNAL, in Vol. I, No. 1, October, 1928, was divided into several sections, which have been continued to the present time. These sections were Sewage Research, Sewage Works Operation, Industrial Wastes and Stream Pollution. Later a section on Operators' Reports was added, and this was changed to The Operators' Corner when it was taken over by Mr. Wisely.

Thus it is possible to assign the relative importance of these divisions, as the years have passed, by pages published annually under each section heading. Although comparison of pages may not necessarily measure the relative worth or value of the various divisions, a list of pages does indicate the proportion of the JOURNAL's available space that has been devoted to each division.

The following tabulation gives the pages under each heading for the past seven years. The page size was increased in 1936, so this is a logical starting point for the comparison.

SEWAGE WORKS JOURNAL
Classification of Subject Matter—Pages

Year	Sewage Research	Plant Operation and Operators' Corner	Industrial Wastes	Stream Pollution	Reviews and Abstracts	Total
1936	356	401	21	48	103	929
1937	378	447	17	17	108	967
1938	331	411	96	64	71	973
1939	384	375	126	19	66	970
1940	329	412	88	59	109	997
1941	255	458	63	125	105	1080*
1942	260	606	71	89	80	1158*

* Including Advertisers' Contributions.

The last column shows the substantial increase in number of pages of subject matter. From 1937 through 1939 the average was 970; since then there has been a steady increase, averaging 80 pages per year for the past two years.

More important than this total increase, however, has been the increase in pages devoted to Plant Operation and The Operators' Corner. The average from 1936 through 1940 was 409 pages; this increased to 458 in 1941 and to 606 in 1942. The Operators' Corner amounted to 134 pages in 1940, 158 in 1941, and 285 in 1942. Mr. Wisely took over this section in May, 1941. His outstanding success in developing this part of the JOURNAL is indicated by these figures. His Corner certainly can't be defined by Webster as "an out-of-the way place; a nook," but maybe by "the state of things produced by a person or persons who buy up the whole or the available part of any stock or species of property.'' We don't believe Pete has cornered all operators' material in the country, but only most of it. Also he has not bought it—he has obtained it by much correspondence and editing.

The sewage works operators ought to be pleased by this proof of the attention being given to their interests. Research must not be allowed to occupy any less space than it has for the past two years, but it may not require much more space during the war. Industrial waste disposal is the section that ought to show substantial increase in the next few years.

The Editor would appreciate any letters from readers of the Journal concerning this record, and trends of interest for the future. The Journal is unique in many ways, and it will retain its individuality if it reflects the interests, aims and aspirations of the loyal members and subscribers who have supported it so faithfully. When the Federation was reorganized two years ago, some advisers insisted that it would be fatal to require full subscription to the Journal for membership in the Federation, and therefore the half-time privilege was established, whereby only three issues per year could be obtained at a proportionately reduced rate. It is surprising and gratifying to the Editor to note from Mr. Wisely's report, which will be published in our next issue, that there were only 53 such half-time subscribers last year, as compared with 2324 full-time subscribers. There were 30 half-time members in one association, 17 in another, 4 in another (New York, with 508 full-time—a complete refutation of the forebodings) 1 in each of two other associations, and none in the remaining twenty-three associations. Because of this loyalty, and possibly sacrifice for many poorly-paid operators, we hope the Journal will continue to deserve their support, and will give them their money's worth.

F. W. Mohlman

Federation Affairs

THIRD ANNUAL CONVENTION

NATIONAL CONFERENCE ON WAR TIME SANITATION

Cleveland, Ohio

October 22–24, 1942

The Third Annual Convention of the Federation of Sewage Works Associations was held at Cleveland, Ohio, October 22–24, 1942, as a Conference on War Time Sanitation, in conjunction with the meeting of the Ohio Conference on Sewage Treatment. Total registration was 412, including 26 ladies. Some 27 exhibitors were present but the exhibits were considerably simplified and did not require operators or attendants. Likewise entertainment was modified to wartime standards, although what was presented was excellent and satisfied everyone. Ladies' entertainment included the usual luncheons, fashion shows and a bridge party. The featured speaker was Dr. John V. N. Dorr, who spoke at the Federation Luncheon Friday noon. His topic was "Genealogy of Modern Sewage Treatment, a Product of Sanitary, Chemical and Metallurgical Engineering." He gave a fascinating review of the development of use of mechanical equipment in sewage treatment, starting with the Dorr thickener in 1913. Reminiscences of his work in metallurgy, and of his early training in the laboratory of Thomas A. Edison, added human interest to the saga of Dr. Dorr's distinguished career.

The technical program was again, as in past years, arranged to suit the plant operator. He had a complete session Friday afternoon, and, as usual, a curtailed session Saturday morning. The latter, "Significance and Value of Laboratory Tests in Sewage Plant Operation," led by Le Roy W. Van Kleeck, was headed off long before the operators were through talking about B.O.D., sampling, grease, etc., to make way for the business meeting at 11:00 A.M. President Bedell had set, as one goal, strict adherence to the program's time schedule, and he nearly made the goal, except for some interference on Friday morning. However, even if the operators had been given all Saturday morning, plus the afternoon, they would still probably have had to be cut short, because they never tire of discussing laboratory and plant problems, and the time allotted is never enough.

A very important feature of the technical program was the discussion of "Priorities," which had been arranged by Secretary Wisely and Vice-President (then, now President) Schroepfer. The report of this clinic is given in the "Operators' Corner" in this issue.

All speakers on the technical program were present except Prof. H. E. Babbitt, whose paper "The Need for Short Training Schools in Sewage Treatment During the Present War Emergency" was read by title. Two important and timely papers, those by Mr. A. M. Rawn on "The Influence of the National Emergency on Sewage Treatment Problems" and by Lewis H. Kessler and John T. Norgaard on "Operation of Army Sewage Treatment Plants," are printed in this issue. The latter, together with the authors' paper on the same subject in our July, 1942, issue, constitutes an authoritative and exclusive record of the intensely interesting development of sewage treatment in army camps. The authors' frank appraisal of patented and commercially promoted processes deserves warm commendation.

Various side-lights on the Conference included an address by William A. Stinchcomb of Cleveland on "Local Civilian Defense Problems"; the gathering of Frank Woodbury Jones' pet clan of "Quarter Century Operators"; the convention notes and registration list interestingly edited by "Rusty" Symons; the trip to the Easterly Treatment Works Saturday afternoon, where luncheon was served to an overflow crowd prior to inspection of the plant; the Board of Control meeting Saturday night, which lasted from 5:30 to 11:15 P.M., and at which three honorary members were elected, as reported herewith;

and the award of the attendance-mileage cup again to the Central States Sewage Works Association, which had a numerical representation even larger than that of the Ohio group.

The technical program was printed in the September issue, and need not be repeated here. All papers presented will be published in this and succeeding issues. Officers for the ensuing year are:

George J. Schroepfer ....*President*
A. M. Rawn ....*Vice-President*
A. S. Bedell ....*Past-President*
W. W. DeBerard ....*Treasurer*
W. H. Wisely ....*Secretary*
F. W. Mohlman ....*Editor*

The 1943 meeting will be held in Chicago at the Hotel Sherman on Oct. 14 or later. A very cordial invitation was received from the Minneapolis-St. Paul delegation, but the Executive Committee decided that restrictions of wartime travel might make the selection of Minneapolis-St. Paul more precarious than selection of Chicago, the cross-roads of the nation.

The many committee reports and transactions of the Meeting of the Board of Control Saturday night are too voluminous to be included in this issue, but will appear in the January issue. However, membership of the new committees is given below, also the letters proposing three new honorary members, who were elected. Inasmuch as honorary members are restricted to ten, Mr. Orchard advised that great care be exercised in the selection of the remaining six, and mechanism for such selection was voted on by the Board, to be published in the January issue.

F. W. M.

FEDERATION OF SEWAGE WORKS ASSOCIATIONS

Constitutional Committees

(*New Names Italics*)

Executive Committee (President and four Directors)

George J. Schroepfer, *Chairman* (Central States)
A. E. Berry (Canada)
H. E. Moses (Pennsylvania)
D. S. McAfee (Manufacturers)
J. K. Hoskins (Federal)

General Policy Committee (Latest living Past President as Chairman, three Directors, three members-at-large. Three of total to be operators—3 year terms)

A. S. Bedell, *Chairman*
Charles G. Hyde, '43 (California) Member-at-Large
R. E. Fuhrman, '44 (Federal, Operator) Member-at-Large
S. C. Probasco, '45 (New Jersey, Operator) Member-at-Large
N. G. Damoose, '43 (Michigan, Operator) Director
H. E. Moses, '44 (Pennsylvania) Director
V. P. Enloe, '44 (Georgia, Operator) Director

Publication Committee (Editor and at least four Members-at-Large)

F. W. Gilcreas, *Chairman* (New England)
F. W. Mohlman (Editor)
Rolf Eliassen (New York)
R. S. Phillips (No. Carolina)
E. W. Steel (Texas)
Carl Green (Pacific Northwest)
F. M. Veatch, Jr. (Kansas)

F. S. Friel (Pennsylvania)
C. C. Larson (Central States)

Organization Committee (At least three Members-at-Large)

Ernest Boyce, *Chairman* (Kansas)
Fred D. Bowlus (California)
R. H. Suttie (New England)

Sewage Works Practice Committee

Morris M. Cohn, *Chairman* (New York)
F. W. Mohlman, Editor (Central States)
C. E. Keefer (Maryland-Delaware)
John Brooks (New England)
G. P. Edwards (New York)
Harold F. Gray (California)
J. J. Wirts (Ohio)
John R. Downes (New Jersey)
A. H. Niles (Ohio)

Research Committee (At least 5 Members-at-Large appointed by Chairman, President concurring)

W. Rudolfs, *Chairman* (New Jersey)
Thomas Camp (New England)
E. J. Cleary (New Jersey)
G. P. Edwards (New York)
H. A. Faber (New York)
A. J. Fischer (New York)
H. Heukelekian (New Jersey)
K. L. Mick (Central States)
L. R. Setter (New Jersey)
S. I. Zack (New York)
H. W. Gehm (New Jersey)

Joint Committees (of some Years' Standing)

Nomenclature Committee (Three members serving with similar Committees of the A. S. C. A. and A. P. H. A.)

F. W. Jones, *Chairman* (Ohio)
O. J. Velz (New York)
C. E. Keefer (Maryland-Delaware)

Standard Methods for the Examination of Sewage Committee

W. D. Hatfield, *Chairman* (Central States)
George Symons (New York)
S. E. Coburn (New England)
A. J. Fischer (New York)
G. P. Edwards (New York)
E. W. Moore (New England)
D. E. Bloodgood (Central States)
F. W. Gilcreas (New England)
E. F. Hurwitz (Central States)
A. J. Castro (California)
W. S. Mahlie (Texas)
M. Starr Nichols (Central States)
Richard Pomeroy (California)
C. C. Ruchhoft (Federal)
William Rudolfs (New Jersey)

New Committees (Appointed in 1941 in Accordance with Recommendation of General Policy Committee)

Awards Committee

C. G. Hyde, *Chairman* (California)
E. S. Chase (New England)
G. P. Edwards (New York)
C. C. Larson (Central States)
H. E. Moses (Pennsylvania)

Operating Report Committee

A. F. Dappert, *Chairman* (New York)
A. E. Babbitt (Central States)
W. A. Allen (California)

Publicity and Public Relations Committee

N. S. Nussbaumer, *Chairman* (New York)
D. E. Bloodgood (Central States)
H. R. Hall (Maryland-Delaware)
W. L. McFaul (Canada)
Prof. E. L. Waterman (Iowa)
Prof. E. G. Tyler (Pacific Northwest)

Operator's Qualifications Committee

L. W. Van Kleeck, *Chairman* (New England)
A. F. Dappert (New York)
P. J. Kleisser (Central States)
M. W. Tatlock (Ohio)
B. V. Howe (Rocky Mountain)

War Service Committee (Formerly *Civilian Defense Committee*)

R. E. Fuhrman, *Chairman* (Federal)
R. F. Goudy (California)
Dana Kepner (Rocky Mountain)
L. S. Kraus (Central States)
W. B. Redfern (Canada)
W. F. Welsch (New York)
T. T. Quigley (New York)

Post War Planning Committee

A. M. Rawn, *Chairman* (California)
Earl Devendorf (New York)
Langdon Pearse (Central States)
William Piatt (No. Carolina)
William Raisch (New York)
William Storrie (Canada)

Finance Advisory Committee

W. J. Orchard, *Chairman*
G. J. Schroepfer (President)
A. S. Bedell (Past President)

Honorary Members

Three new Honorary Members were elected by the Board of Control in accordance with the following proposals from member associates. C. A. Emerson was elected in 1941.

RESOLUTION

Nomination of Mr. Langdon Pearse—Honorary Membership

WHEREAS, Mr. Langdon Pearse is one of the founders of Central States Sewage Works Association and a member of said Association for many years, and

WHEREAS, Mr. Pearse has vast practical and scientific knowledge in matters relating to the nature, collection, treatment, and disposal of sewage, and

WHEREAS, he has labored diligently to advance knowledge concerning design, construction, operation, and management of sewage works, and

WHEREAS, Mr. Pearse has been a leader in the encouragement of the friendly exchange of experience in matters pertaining to sanitation, and

WHEREAS, Mr. Pearse labored quietly but at great length to prepare the volume, "Modern Sewage Disposal," and

WHEREAS, Mr. Pearse is a congenial gentleman, a good friend, and a man's man,

Therefore, Be It Resolved, that Mr. Langdon Pearse be, and he hereby is, nominated by Central States Sewage Works Association for election to Honorary Membership in the Federation of Sewage Works Associations.

Passed by Executive Committee of *Central States Sewage Works Association,* October, 1942.

J. C. MACKIN,
Secretary-Treasurer

To the Board of Control
Federation of Sewage Works Associations

In accordance with the action taken by the Executive Committee of the New England Sewage Works Association on September 23, I am pleased to present to the Board of Control of the Federation of Sewage Works Associations the name of Julius W. Bugbee of Providence, Rhode Island, for election to the grade of Honorary Member of the Federation.

Mr. Bugbee was graduated from the Worcester Polytechnic Institute in the class of 1890, receiving the degree of Bachelor of Science in chemistry. He became chemist in charge of the operation of the Worcester sewage treatment plant in 1892, serving there until 1901 when he became supervising chemist and operator of the Providence sewage treatment plant, a position which he holds at present. He has, therefore, been continuously active in the profession of sewage plant operation for a period of fifty years, and is without doubt, the dean of all sewage plant operators in the United States.

In addition to his services as an operator, Mr. Bugbee has been prominent in professional activities during his fifty years of service. He was a member of the group responsible for the organization of the New England Sewage Works Association in 1929, and served that Association as Vice-President in 1929 and 1930 and as President in 1934. He was the Director representing the New England Association on the Board of Control of the Federation in 1931 and 1932, and served as Vice-Chairman of the Federation during 1934. He has always taken an active part in the technical societies with which he has been connected, being a most regular attendant at all meetings, including that of the Federation in 1941 when he became a charter member of the Quarter Century Operators' Club.

In view of his professional attainments, his many contributions to the science of sewage treatment, and his long record of efficient service, the New England Sewage Works Association feels that he has amply merited the distinction of honorary membership in the Federation and hopes that favorable consideration will be given his nomination for this honor.

F. WELLINGTON GILCREAS,
Director for the New England Association

NEW YORK STATE SEWAGE WORKS ASSOCIATIONS

Sept. 21, 1942

Resolution

WHEREAS, Arthur S. Bedell has rendered outstanding and meritorious service to the Federation of Sewage Works Associations as member and chairman of the important Federation

Re-organization Committee, as Vice-President of the Federation and as President of the Federation during the troublesome year just past, and

WHEREAS, his years of continuous service as the Secretary-Treasurer of the New York State Sewage Works Association has contributed in great measure to the outstanding growth of this Association, and caused this Association to add strength and solidarity to the Federation of Sewage Works Associations, therefore be it

Resolved, that the New York State Sewage Works Association, through its Executive Committee, nominates and indorses Arthur S. Bedell, President of the Federation of Sewage Works Associations, as an honorary member of the Federation, upon the completion of his term of office in October 1942.

CHARLES R. VELZY, *Chairman*
JOSEPH E. REHLER
W. H. LARKIN
WILLIAM RAISCH
ROBERT C. WHEELER
W. L. MALCOLM
WM. D. DENISE
EDWARD J. SMITH

Reviews and Abstracts

EXPERIMENTAL WORK TO IMPROVE THE PERFORMANCE OF A BIO-AERATION PLANT

The Surveyor, 101, 201–202 (June 12, 1942)

The following are excerpts from discussions of paper by John Hirst previously abstracted and reported in the September, 1942, issue of the SEWAGE WORKS JOURNAL.

Mr. C. Lumb suggested that the most economical manner of providing additional preliminary treatment at Sheffield would be to convert the existing secondary sedimentation tanks to pre-aeration units adding the return sludge from the final settling tanks of the Sheffield units, the sludge being first re-aerated if necessary in new re-aeration tanks. He commented upon the unusually large chemical requirements due evidently to the high alkalinity of the sewage. Results obtained by using ferric salts in conjunction with acid checked similar results at Halifax, namely, greater precipitation than with either agent alone. Greater success with bio-aeration at Sheffield might be attributed to the iron content of Sheffield sewage.

Mr. R. L. Moore had experienced difficulties with the Brighouse bio-aeration plant similar to those at Sheffield. He felt that return of a heavier activated sludge would enable the plant to treat the extra flow. Mr. F. Oliver stated similar troubles had occurred at Rotherham with a Haworth plant. A solution to the trouble was found by feeding a mixture of final effluent and filter effluent to the bio-aeration units.

Dr. W. Watson stated that some troubles were experienced at most activated sludge plants where aeration was not used in conjunction with some other method of purification such as percolating filters. He felt that this was due to over-optimism on the part of designers as to the capabilities of the activated sludge process leading to underdesigned plants. He stated that if lack of aeration was a cause of bulking troubles, the troubles might be overcome by (a) diluting the sewage with effluent if a long series of tanks was used; (b) using a lesser number of tanks in series; (c) adding only a portion of return activated sludge at the beginning of the aeration period and adding the remainder about half-way down the plant when the oxygen demand had been reduced.

K. V. HILL

THE EFFECT OF CHROMIUM COMPOUNDS ON THE PURIFICATION OF SEWAGE BY THE ACTIVATED SLUDGE PROCESS

BY S. H. JENKINS AND C. H. HEWITT

The Surveyor, 101, 211–212 (June 19, 1942)

The authors discuss the effect of chromium compounds in sewage upon sewers, trickling filters, and the operation of the activated sludge process.

They state that chromium compounds do not cause heavy deposits in sewers due to the fact that the precipitants formed by the reaction of chromates with sewage are light and bulky and not likely to settle out.

References are given to three sources in the literature regarding experiments by others with chromium wastes: viz.,

(1) Monk, H. E., "Some Chemical and Bacteriological Properties of Trade Wastes Containing Chromates," *J. and Proc. Inst. Sewage Purification*, pp. 9–16 (1939).

(2) Spencer, J. H., "The Treatment of Chromium Plating Waste," *J. and Proc. Inst. Sewage Purification*, pp. 17–30 (1939).

(3) Jenkins, S. H., and Hewitt, C., "The Effect of Chromate on the Purification of Sewage by Treatment in Bacterial Filters," *J. Soc. Chem. Ind.*, 57, 41–44 (1940).

Regarding the effect of chromates upon the purification of sewage in laboratory trickling filters, the authors conclude,

1. 0.1 part chromium per 100,000 indicated loss in nitrate in the filter effluent and somewhat more B.O.D. than in the control filter unit dosed without chromate. 1.0 part chromium per 100,000 was sufficient to convert a good effluent into one of moderate quality. With 10 parts of chromium per 100,000 nitrification was reduced about 70 per cent and organic impurities were about twice as great as in the control filter effluent.
2. Chromates induced deposits in the upper layers of the filter.
3. Dry solid matter in the upper part of the filter fed with sewage containing 10 parts of chromium contained 5.2 per cent of chromium indicating that 1.2 out of the 10 parts of chromium were retained by the filter.
4. The solids deposited in the dosing tank contained 26 per cent of chromium.

Some reduction of organic matter took place in the filters even with 10 parts of chromium per 100,000 present in the sewage. The tentative conclusion of the experimenters was that the continued presence of 1 part of chromium as chromate per 100,000 did not prevent substantial purification but did accelerate clogging of the filters.

In the activated sludge process 0.2 parts chromium as chromate per 100,000 will reduce or even stop nitrification. One part chromium as chromate per 100,000 present continuously for two days may cause nitrification to cease and require a week or more to restore the sludge to normal activity.

Chromium appears to have a specific inhibitory action upon nitrifying organisms. The action is not toxic.

There is a pronounced difference between the action of chromium supplied as chromate and as chrome alum. Chromate stops nitrification and decreases biological activity of the activated sludge. Chrome alum has no effect on nitrification (at concentrations higher than those of chromate which do effect nitrification); it does enhance flocculation and does not interfere with biological activity. Thus, reduction of chromate to a chromous state in chromium plating waste should precede treatment of the waste by activated sludge. Chromates are rapidly reduced to the chromous state by a reducing agent such as sulfur dioxide.

K. V. Hill

MANURIAL VALUE OF SEWAGE SLUDGES

By E. M. Crowther and A. H. Bunting

The Surveyor, 101, 255–258 (July 24, 1942)

A paper on this subject was presented at the annual summer meeting of the Institute of Sewage Purification by the authors who are members of the chemistry department of the Rothamsted Experimental Station. The authors introduce their paper with the statement that they have no intention of attempting to answer the question which the title implies, but rather desire to consider some of the questions which have to be answered in this connection and to describe their field experiments.

Soil organic matter content and soil fertility are discussed at some length and the authors point out the correlation between the two. Two ideal soils are described, the "Black Earth" of Central Russia and "brown earths" of broad-leaved forests. In the former, long cultivation of the land under grass allowed the roots to build up considerable soil organic matter and to crumb the soil. In the latter, worms carried organic matter from the surface into the ground and incorporated it into the soil. In contrast to these soils there are others rich in organic matter, but which for some reasons such as excessive moisture, or lack of lime and other bases, or proper incorporation and rotting of organic matter, may be quite infertile.

The authors point out that manuring alone is not enough to build up good soils; rotation of crops is also necessary. They also call attention to the differences in manures due to differences in stock feeding.

The ratio of carbon to nitrogen in manures is important. Manure rich in carbohydrates and low in protein may actually be the cause of nitrogen removal from the soil because the organisms which attack carbohydrates require definite quantities of ammonia or nitrate. To illustrate this fact the authors cite poor results obtained from the use of a dressing of straw and town refuse. Sewage sludges are unlikely to have this effect because their nitrogen percentages are normally above the critical value. However a considerable portion of the total nitrogen in sewage sludge has little or no manurial value because it is in such inert form that it has resisted fermentation for a long time and because some of it is required by the organisms which continue these fermentation processes in the soil. On the other hand high nitrogen concentrations may be wasteful because much of the nitrogen may be lost as ammonia or free gas.

Farm yard manures and sewage sludges both contain phosphoric acid, but the phosphorus in manure is more readily available. Sewage sludges are deficient in potash. Farm yard manures, being derived from plant residues, contain some quantity of all the elements found in plants. Hence they often seem to overcome deficiency diseases. Sewage sludges do not have this quality.

Experiments on fertilizing potato crops indicated that farm yard manure, where no potash was added, increased the yield from 3.6 to 9.1 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 their weight of manure.

The authors review briefly nine types of sludges and their merits and demerits, as follows:

1. Raw primary and humus sludge—nitrogen content usually 2 to 3 per cent of organic content—hard to dewater and handle.
2. Raw primary acid precipitation sludge, heat dried and de-greased, containing textile residues—nitrogen content usually 2 to 3 per cent of organic content—light and open texture—easy to handle—but unless sufficiently wetted decompose slowly.
3. Raw primary lime-pressed sludge—nitrogen content usually less than 2 per cent of organic content—may have to undergo preliminary weathering in order to render it more friable.
4. Raw primary sludge with activated sludge—nitrogen content about 6 per cent of organic content—difficult to dry and hard to handle.
5. Activated sludge when dried has the highest nitrogen percentage (10 per cent) and the nitrogen is more rapidly available in the soil.

Finally the authors attempt to prophesy what may happen after the war to the method and practice of applying the by-products of sewage treatment processes to the land, and point out that with power available from the sewage itself, some means should be found to apply economically the two most valuable products, water and soluble nitrogen, to the land.

K. V. Hill

SANITATION FACILITIES FOR MILITARY POSTS

By S. A. Greeley and E. S. Chase

Civil Engineering, 12, 359 (July, 1942)

The authors review their recommendations made in 1940 for the design characteristics of sewage treatment plants at army posts and compare them with results obtained after a year of operation. Graphs are presented to show hourly variations in flow indicating a morning peak at 8 A.M. of 180 per cent of the average flow and an evening peak of approximately 150 per cent of average lasting from 6 until 11 P.M. The minimum flow reached a low of 30 per cent of average at 3 A.M. A graph is presented to prove that the daily flow does not reach an average of the estimated 70 gal. per capita, except at the largest plants. Consumption tends to vary inversely with population.

Sewage characteristics have been analyzed and it was found that while the predicted value of suspended solids was 0.27 lb. per capita daily, the average at 10 plants has indicated only 0.20 lb. Conversely, the predicted B.O.D. value was 0.17 lb. while the actual has been 0.20 lb. Great variations from these values have been noted in many plants, depending on installations at the post.

A statement is presented to the effect that the authors do not consider grit chambers essential, but no operating data are presented to convince the reader that separate sewers at army posts are any less free from infiltration and grit than the typical municipal system.

Operating data are meager and do not indicate what might be expected at typical plants, as results from only three plants are considered. B.O.D. removals of 50 per cent had been predicted, but the average is only 40 per cent. Since original recommendations for secondary treatment were made on the basis of a raw sewage B.O.D. of 0.17 lb. per capita per day and a removal of 50 per cent in the primary clarifiers, the actual removal of only 40 per cent or a raw sewage B.O.D. of 0.20 lb. per capita has resulted in an increased B.O.D. load of 40 per cent on the secondary units. This has not resulted in any serious lowering of plant efficiencies. Secondary treatment consisted principally of low and high-rate trickling filters. Activated sludge was looked upon with favor.

Civilian operators are in charge of all plants. The authors express the hope that operating data will be forthcoming and that it will be made available for publication to assist in formulating policies for future designs.

Rolf Eliassen

SEWAGE DISPOSAL IN A SOUTHERN ARMY CAMP

By R. M. Lingo

Civil Engineering, 12, 206 (April, 1942)

The author describes the layout and operation of a sewage treatment plant for an Army camp serving 55,000 men. The flow sheet involves a grit chamber, comminutor, primary clarifiers, chlorine contact tank, two-stage sludge digestors, and sludge drying beds. Nothing unusual entered into the design of this plant. Pre-chlorination to the extent of 2 p.p.m. and post-chlorination of 8 p.p.m. are practiced.

Considerable difficulty was experienced at first in bringing the pH of the sludge in the digestors to the point of neutrality. Lime was added in quantities up to 2,000 lb. per 35,000 cu. ft. of tank by placing milk of lime into a clarifier scum pit and pumping it into the digestors. Better results were obtained by adding the milk of lime to the top of the digestors through the roof. Heating coils were installed but never used in the southern climate. No analytical results of any value were presented in this article.

Rolf Eliassen

EMERGENCY TREATMENT OF ARMY CAMP SEWAGE

By Frank Bachmann

Engineering News-Record, 129, 107 (July 16, 1942)

Emergency sewage treatment which can serve until permanent facilities are constructed is one of the operating problems met with at army posts. Sewage treatment plant equipment frequently is not ordered until the job has progressed and water and sewer lines, as well as buildings, may be ready for troops before the plant is fully equipped and ready to operate as designed.

Methods of equipment procurement are discussed by the author. Some engineers prepare complete structural drawings and have the equipment purchased by the contractor. A faster method is to issue equipment specifications, call for bids on these, then design according to the layouts submitted by the successful equipment manufacturers. The greatest time saving method is to utilize allocation contracts for equipment, as permitted by the War Department.

Experience has shown that contractors have been able to build the concrete structure of the sewage treatment plant long before the arrival of the equipment to be installed in the tanks, etc. Where the settling tanks are constructed, it is suggested that they be used without equipment to accomplish some degree of treatment.

Lime to the extent of 600 to 1,500 lb. per M.G. of sewage can be added to give a causticity of 10 to 20 p.p.m. As it settles the carbonate floc formed will carry with it the suspended solids. The main items needed are a chemical feeder and a mixing device. The latter may be arranged by installing a temporary baffle in the channel leading to the primary settling tank, or ahead of a Parshall flume in this channel.

The author claims a suspended solids removal of 90 per cent and a B.O.D. removal of 70 per cent. These values are based on the results of experiments on a strong Wisconsin sewage containing creamery wastes. Removals as high as these can hardly be expected at an army camp, even though the sewage is relatively fresh.

The sludge resulting from this treatment can be disposed of on sand beds without nuisance. Sewage solids are diluted with the mineral precipitates and the caustic sludge will not attract flies.

Until the sludge removal mechanism can be installed, the sludge will accumulate in the sedimentation tanks. As most of these tanks have a slight slope, some sludge can be removed by simply opening the sludge draw-off line. The balance of the sludge can be moved periodically to the sludge draw-off by hand squeegees. The causticity will prevent any appreciable septic action. Grease will precipitate with the sludge and little scum should result.

As a temporary expedient to permit troops to be moved into the camps where tanks are available but where equipment delivery is delayed, this method should give results which will remove solids from sewage without objectionable conditions arising.

Rolf Eliassen

JOURNAL, NORTH CAROLINA SECTION, AMERICAN WATER WORKS ASSOCIATION

Volume 17 (1942)

The Treatment of Sewage Using Intermittent Sand Filters. By Robert Howell Grady, pp. 76–88. The cost of maintenance of sand filters for secondary treatment is negligible. Many filters of this type have been known to produce a satisfactory effluent even when subjected to neglect and a lack of operating attention which would have unquestionably put other equipment out of service. Except in cold climates, and where land values are high and suitable sand is unavailable or costly, sand filters should be economical for moderately sized plants. The problem in North Carolina is to find a cheaper method of sewage treatment, yet efficient enough for use in small communities, schools and other state institutions.

The practice has been to specify a sand depth of 2 or 3 feet, and a very definite and costly grading of sand. Since the quantity and quality of sand are the principal items of cost, it would be desirable to reduce the quantity and to find cheaper sands which would be satisfactory.

Research was undertaken to determine whether it is practicable (1) to reduce the costly grading of sand, (2) to reduce the depth of sand, and (3) to increase the rate of dosage.

The sewage used in the tests was obtained from the sewage plant at the North Carolina State School for the Blind and Deaf, Colored Division, near Raleigh. Sewage was syphoned from the septic tank daily and hauled to the experimental filters in 15-gallon kegs. The detention period in the septic tanks was not known.

The sand filters were constructed of 8-in. glazed terra-cotta pipe placed vertically on clay building blocks, spigot end downward. The base of each filter was concrete, sloped to a ½-in. outlet at the center. Sand was supported by three 3-in. layers of gravel, graded as follows:

Bottom layer—¾-in. to 1½-in.
Middle layer—¼-in. to ¾-in.
Top layer —⅛-in. to ¼-in.

Dosing was accomplished by means of dippers calibrated to give the exact rate desired. A rate of 125,000 gallons per acre per day was selected as the rate generally accepted in standard practice. The rate of 200,000 gal. per acre per day was used to study the effect of higher rates. Depths of 9, 12, 18, 24, and 30 inches were used. The table below shows the sizes used, the uniformity coefficient, and the time the various filters were tested.

Effective Size mm.	Uniformity Coefficient	Months Operated
0.20	2.0	1
0.30	2.0	6
0.33	4.5	4
0.50	2.0	2

The following table shows the per cent reduction in 5-day B.O.D. for the various depths and sand sizes.

Depth Inches	Effective Size mm.				Effective Size mm.			
	0.20	0.30	0.33	0.50	0.20	0.30	0.33	0.5
	125,000 Gal. per Acre per Day				200,000 Gal. per Acre per Day			
9	95.8	90.4	85.9	73.5	91.8	85.5	76.2	67.5
12	97.9	91.5	88.8	74.1	95.8	87.8	77.2	71.0
18	97.2	97.2	89.8	82.2	96.4	89.0	84.4	70.4
24	99.0	98.1	95.5	86.0	98.2	94.0	90.0	74.8
30	98.5	98.8	96.7	82.8	98.0	96.1	92.6	80.0

(NOTE: Figures in the above table were read from graphs presented in the paper.)

The filters with sand with an effective size of 0.20 mm. showed serious signs of clogging within a month.

Round Table Discussion of Sewage Treatment Problems, pp. 100–106. The first topic discussed was time and velocity of mix in treating industrial wastes with a coagulant. One operator reported that lime was found to be the most economical coagulant for both sulfur black dye wastes and for direct dyes.

It was reported that work carried on by the Textile Foundation showed that velocity and time of mix varies with each waste and with each coagulant. With large amounts of sulfur present a large amount of iron sulfide, as well as hydroxide of iron, is precipitated. Iron sulfide does not stand mixing well, and a rapid mix with little flocculation is best. It was stated that iron salts are better than alum for sulfur dyes.

At another plant, receiving dyes from the silk industry and also cotton dyes, alum is used. Floc formation and B.O.D. reduction vary with the type of waste received. A flash mixer is used, and at times it is found unnecessary to use the flocculator.

There was some discussion of the treatment plant at Fort Bragg, where a single-stage filtration plant employing recirculation is used.

The meeting closed with a discussion of grease removal.

T. L. HERRICK

JOURNAL OF THE MISSOURI WATER AND SEWAGE CONFERENCE

Volume 13 (1942)

The Maintenance of Sewerage Systems. By Harry H. Chaffee, pp. 38–42. In this paper the causes of clogging in sewer lines are discussed, along with methods of removing obstructions. Methods of maintaining satisfactory flow conditions are described.

The Use of Paint in Sewage Treatment Plant Maintenance. By F. D. Travis, pp. 43–44. The author suggests the use of coal tar paints and lead-free synthetic enamels as being more satisfactory than standard types of oil-paints. Coal tar paints are recommended for use wherever protection is wanted and appearance is not essential. Proper preparation of the surface is stressed.

Some Phases of Sewer Operation and Maintenance. By W. B. Rollins, pp. 45–46. In this paper some of the more general aspects of sewage collection and treatment are discussed.

Continuous Maintenance. By George L. Loelkes, pp. 47–49. This paper points out the necessity of a regular program of inspection and adjustment of all mechanical and electrical equipment as a means of "preventative maintenance."

Maintenance of Sewage Pumps, Sludge Pumps, and Their Auxiliary Equipment. By Philip F. Morgan, pp. 50–55. Many valuable suggestions are given on the proper installation and care of all types of pumps used in sewage works. Methods of overcoming operating difficulties are discussed.

T. L. Herrick

PROCEEDINGS, FIFTEENTH ANNUAL CONFERENCE, THE MARYLAND-DELAWARE WATER AND SEWAGE ASSOCIATION (1941)

The Anacostia River Sewage Treatment Works of the Washington Suburban Sanitary District. By Harry R. Hall, pp. 16–21. In 1938, a sportsmen's group and a Washington newspaper started a campaign against pollution of the Potomac River and an injunction was obtained against the Washington Suburban Commission preventing them from discharging untreated sewage into the Anacostia River.

Studies were made in cooperation with the district officials of the District of Columbia to see if it would be cheaper to construct sewers in order to discharge the sewage into the Blue Plains Plant at Washington, D. C., or to build a separate treatment plant. The latter was found to be the cheaper based on an estimated cost of $700,000 for an activated sludge plant of 7.5 m.g.d. Lowest bid received was $1,259,000 and so primary sedimentation and sludge digestion were resorted to.

The completed plant will handle 7.5 m.g.d. and provides for primary sedimentation, chlorination of the effluent, sludge digestion, elutriation and vacuum filtration. The total cost of the plant was $796,500. This price did not include the land as the District already owned the land.

The average sewage has a B.O.D. of 155 p.p.m. which is reduced to 70 p.p.m. and the suspended solids are 130 p.p.m. which are reduced to 45 p.p.m.

The paper is discussed by A. L. Genter and Ralph E. Fuhrman.

Principles and Factors Influencing Vacuum Filtration of Sludge. By Albert L. Genter, pp. 46–75. Factors governing the rate of flow of liquid through a cake filter medium and permanent filter medium and hence governing filter yield, are: (1) Water present in the sludge, (2) filtration pressure, (3) rate of solids deposit in the filter cake, (4) resistance of permanent medium to the flow of liquid, (5) resistance of the filter cake to the flow of liquid, (6) time, (7) coefficient of viscosity, (8) temperature, (9) diameter of drum, (10) number of suction compartments in the drum surface, (11) speed of the drum (relates factors 3 and 6), (12) amount of drum surface submerged in the sludge bath, (13) kind and condition of filter cloth, (14) homogeneity of the sludge in the filter tank, (15) amount of vacuum during filtration and drying, (16) blowing pressure for discharging the cake, (17) effectiveness of draining filtrate completely from the revolving suction compartments, (18) minimum cake thickness which can be effectively discharged and (19) uniformity conditions conducive to continuous operation.

The effect of mineral matter in any sludge is to increase the specific gravity and stable structure of the sludge particle and the percentage of solids concentrated in the sludge and the filter cake. The effect of organic matter with low specific gravity is just the opposite. This is the chief distinction between metallurgical and industrial chemical slimes and sewage sludges. In sludge filtration the primary concern is with the capillary properties of the aggregates in suspension. The porous aggregates common to sewage solids lack a stable structure; therefore, they quickly smear or cover a filter medium with an impervious coating. Sludge conditioning by the use of chemicals is required to give them a more stable structure which allows the removal of excess moisture by a filter.

Chemical conditioning introduces new factors whose influence is chiefly dependent on (1) the amount of volatile matter present in the sludge solids and (2) concentration of substances such as ammonium bicarbonate in the sludge moisture.

The paper continues with a searching discussion of the factors affecting, and the principles of, the vacuum filtration of sludge. The important discrepancies between Beuchner funnel laboratory tests and actual plant results are pointed out and accounted for.

Eight figures. Two tables. Discussion by Paul D. McNamee and Herman Kratz.

What the Federation of Sewage Works Associations is Doing and What It Means To Us. By Charles A. Emerson, Jr., pp. 78–81. The author comments briefly on the history of the Federation and its aims and activities.

PAUL D. HANEY

OHIO CONFERENCE ON SEWAGE TREATMENT

(Fifteenth Annual Report, 1941)

Development of Sewage Treatment in Ohio. By F. H. Waring, pp. 17–25. The first municipal sewage treatment plant in Ohio was constructed at Canton in 1893. Treatment consisted of chemical precipitation. Sludge was dewatered by presses. There are at present 182 treatment plants in the state. The greatest growth has been over the period 1930–1940 during which the number more than doubled. The population served is in excess of 3.2 million.

Distribution as to type of treatment is as follows:

	Number	Pop. Served
Activated Sludge	27	1,086,364
Sand Filters	28	72,856
Trickling Filters	50	1,105,223
Contact Beds	7	29,588
Chemical Precipitation, only	9	110,065
Plain Sedimentation	54	823,596

According to degree of treatment:

			% Total Sewered Pop.
Complete	131	2,264,443	46
Partial	78	963,249	19
None	307	1,734,645	35

Four tables, two charts.

Sanitation Problems in Connection With National Defense. By B. F. Hatch, pp. 26–32. A discussion of military as contrasted to civilian sanitation, communicable disease control, water supply, garbage and refuse disposal, mosquito control, housing and venereal diseases.

Cannery Waste Treatment. By N. H. Sanborn, pp. 33–38. Cannery wastes may be classified as follows: (1) Solid wastes from trimmings discarded raw material, etc. and (2) cooling tank water. This should not be allowed to dilute other wastes if treatment is necessary as its value as a diluent is more than offset by increased plant facilities required. (3) Silage juice. One sample of pea silage was found to have a 5-day B.O.D. of 78,000 p.p.m. Corn silage has a B.O.D. of approximately 30,000 p.p.m. (4) Water from washing operations, blanching and factory clean-up. This waste contains large amounts of organic matter and it is with this waste that canners are generally concerned.

Characteristics of cannery wastes vary over a wide range. The 5-day B.O.D. may be as low as 200 p.p.m. or as high as 7,000 p.p.m.

Methods of treatment available for consideration are (1) screening, (2) chemical precipitation, (3) biological filtration, (4) lagooning and (5) treatment at municipal works. Efficient screening is essential in any case. Stationary screens are totally inadequate. Twenty to 40 mesh rotating, water-spray cleaned screens are in general use. Vibrating screens are efficient. Cannery wastes should discharge directly and promptly to the screen chamber.

Two methods of chemical treatment are employed, the continuous flow method and the batch method. The author favors the use of the latter. Lime and ferrous sulfate are usually employed. Sludge is disposed of on drying beds. Large bed capacity is required. Chemical precipitation process is satisfactory as means of pretreatment or complete treatment where a fair amount of stream dilution is available. The cost of a batch treatment plant for a two-line cannery is approximately $3,000.00. Operating costs including depreciation and interest charges are approximately one cent per case of 24 number 2 cans.

Biological treatment of cannery wastes has been confined largely to experimental trickling filters although operating results on one full-size installation are given. An experimental high-rate filter gave B.O.D. reductions 60 to 73 per cent with various wastes exclusive of the reduction obtained in the settling tank.

Excellent treatment of pea, green bean and tomato wastes was accomplished on a standard rate filter at Albion, New York. Operating costs made up of power, labor, and lime for pH correction amounted to $2,630 for 50 million gallons of waste.

Lagooning wastes is acceptable practice but is limited because of odor nuisance, etc. Activated carbon and lime will not prevent odor formation. However, odor control is possible by the use of sodium nitrate (cf. SEWAGE WORKS JOURNAL 14, 4, 928, July, 1942).

The following data are presented in connection with treatment of chemically pretreated cannery wastes at municipal plants equipped with standard rate filters.

Type of Waste	B.O.D. to Filter	Cu.ft./lb. B.O.D.	B.O.D. in Effluent	Filt. and Sec. Tank Eff.	Final Eff. B.O.D.
Plant No. 1					
Settled domestic	235 lb.	117	34 lb.	86%	35 p.p.m.
Corn and domestic	694	44	226	71	128
Plant No. 2					
Settled domestic	443	74	114	74	18
Pea and domestic	2020	19	703	65	30

pH adjustment is necessary when untreated cannery waste is discharged to municipal plants owing to the rapidity with which mixed wastes undergo bacterial decomposition with the production of acids and offensive odors.

Studies of Bathing Beach Waters of Cleveland. By Paul Gieson, pp. 39–42. Bacteriological and microscopic examinations of water from seven bathing beaches on Lake Erie adjacent to the Easterly sewage treatment plant are conducted each summer. Data are presented which indicate that (1) the plant effluent is much cleaner than the shore lake water, (2) the chlorine residual in the effluent has a sterilizing effect on the adjacent lake water, (3) in the three years the plant has been operating a 91 per cent reduction in pollution of the bathing beach waters has been effected and (4) at present the bacterial content is within the upper limits of that recommended by the City of New York for bathing waters.

Mansfield Sewage Treatment Plant Design and Operation. By J. R. Turner, pp. 44–47. Design data and operating results for the Mansfield, Ohio, activated sludge plant are presented. Overall reduction in B.O.D. and suspended solids averaged 94 per cent and 93 per cent, respectively.

The Revitalized Federation of the Sewage Works Associations. By W. H. Wisely and M. W. Tatlock, pp. 48–50. A discussion touching on the necessity for reorganization of the Federation, the manufacturer's place in the new organization, the necessity for increasing dues, the provision made for members in low-salary brackets, and the expanded functions of the Federation.

Semi-Automatic Control of Secondary Solids At the Lima Activated Sludge Plant. By E. E. Smith, pp. 51–53. The method employed at Lima is illustrated by a flow diagram and photograph. A 4-inch value in the return sludge pump header continuously discharges waste activated sludge to the primary settling tank. The amount of such excess sludge is affected immediately by a back-pressure plug in the return sludge discharge line leading to the mixed liquor channel. Advantages of this arrangement are: (1) avoids the necessity of guessing at the number of hours to operate excess sludge pumps, (2) nearly eliminates the operation of excess sludge pumps, (3) reduces power costs and (4) the continuous addition of a small quantity of excess activated sludge has a beneficial effect on primary tank efficiency.

Diffuser Plate Cleaning Versus Compressed Air Costs. By Willard F. Schade and J. J. Wirts, pp. 54–68. Permeability tests were made according to the method suggested by Beck (SEWAGE WORKS JOURNAL, 8, pp. 22–37, 1936). The method of cleaning consisted of (1) soaking the plates for several hours in the cleaning agent, followed by a draining and then by a washing period. Special wash measures were found essential to rid the plates of all cleaning agent. The use of wetting agents in the wash water has been suggested. Gasoline, muriatic acid, nitric acid and caustic soda produced some cleaning effect but these did not approach the efficiency of chromic-sulfuric acid solution. For routine plate cleaning a two per cent solution of sodium dichromate in sulfuric acid is recommended with a soaking time of one to two hours. Cost of plate cleaning, including labor for removal and resetting, is approximately twenty-five cents per plate. There is no appreciable loss due to plate breakage or torn rubber gaskets. It is considered economical to clean plates when the blower discharge pressure increases one-half pound per square inch. Numerous data on permeability and cleaning tests are presented. Three references. Six tables.

Flocculation of Sewage With and Without Chemicals. By Ervin F. Leist, pp. 69–74. The Circleville, Ohio, plant employs chemical precipitation to increase the degree of treatment during the summer and fall seasons. During the remainder of the year primary treatment alone is employed. Data are presented on the removal of suspended solids and B.O.D. by conventional chemical precipitation methods and by a combination of flocculation without chemicals and sedimentation. Five tables.

B.O.D. Dilution Water—Past, Present and Future. By R. D. Scott, pp. 75–76. The author recommends that further studies be made before bicarbonate dilution water is abandoned in favor of the proposed mineralized phosphate dilution water (SEWAGE WORKS

JOURNAL, 13, 669, July, 1941). The author suggests studies on a fortified bicarbonate dilution water whose composition is as follows:

Sodium bicarbonate	300 p.p.m.	as $NaHCO_3$
Calcium chloride	10 p.p.m.	as Ca^{++}
Magnesium sulfate	2	as Mg^{++}
Ammonium sulfate	0.5	as N
Di-potassium phosphate	0.2	as P
Ferrous sulfate	0.05	as Fe

Design Problems to Meet Operating Conditions. By Floyd G. Browne, pp. 77–80. A summary of design features which may influence to a great extent the ease, efficiency, or safety of plant operation.

Operating Data With Special Reference to Small Sewage Treatment Plants. By G. A. Hall, pp. 81–82. The author recommends that the following operating data be kept: (1) daily flow record, (2) daily weather record, (3) by-pass operation record, (4) a record of out-of-service equipment, (5) settleable solids, (6) relative stability and dissolved oxygen on receiving stream and effluent from plants equipped for secondary treatment, (8) occasional 5-day B.O.D. and suspended solids results, (9) chlorine dose and residual if disinfection is employed, (10) amount and character of digested sludge withdrawn and (11) cost of operation.

The desired result is brief reliable records which adequately cover plant operation.

Improved Sewage Plant Operation at Lakewood. By P. A. Williams, pp. 83–89. A discussion of plant operating problems at Lakewood, Ohio. Consideration is given to laboratory control, pump operation work schedules, tank cleaning, digester operation, sludge removal and ground beautification. Effective use has been made of sludge in connection with the latter.

Progress Report of Committee on Corrosion. By Willard F. Schade, chairman, pp. 90–98. A summary of replies to a questionnaire is given. The committee has conducted a survey of the literature and abstracts of articles relating to corrosion and corrosion resistance are presented.

Lancaster Sewage Treatment Plant. By Dwight Keller, pp. 102–105. This plant consists of a grit chamber, screens control house, primary tanks, high rate trickling filters, secondary settling tanks, digesters and sludge beds. The filters were designed for 15 cubic feet of media per pound of B.O.D. At the design flow of 38 m.g.d. the area loading is 20 m.g.a.d. Trouble with ice rings on the filter beds was eliminated by taking one filter out of service and by the use of calcium chloride. Difficulty with chains freezing to sprocket wheels was overcome by running the sludge scrapers continuously. Freezing trouble with the comminutors was similarly eliminated. Ponding of the filters was partially corrected by flooding to induce unloading. Fly nuisance was controlled by weekly flooding. Overall B.O.D. reduction for the period March to June, 1941, varied from 64 per cent to 88 per cent. Suspended solids reduction varied from 74 per cent to 92 per cent. Operating costs averaged approximately $800.00 per month.

Screens and Grit Chambers. By Don Heffelfinger, pp. 106–110. The author presents a general discussion of the theory and operation of various types of screens and grit chambers. Consideration is given to various types of equipment and methods of disposal of screenings and grit.

Group Discussions, pp. 111–119. Group discussions on Maintenance of Sewage Works, Activated Sludge Treatment, Sewage Filtration, Sewage Sludge Treatment and Disposal, Laboratory Practice and Control are briefly reported. During the latter session a resolution was passed recommending that a study of mineralized, bicarbonate B.O.D. dilution water, such as that proposed by R. D. Scott, be undertaken.

PAUL D. HANEY

BOOK REVIEW

INDUSTRIAL WASTE GUIDES

OHIO RIVER POLLUTION SURVEY

U. S. Public Health Service, Cincinnati, Ohio, October, 1942

For a long time there has been need of an authoritative and comprehensive manual on the composition, volume, and methods of disposal of industrial wastes. The U. S. P. H. S. has been interested in this problem for many years, and collected available information on unit quantities and equivalents some fifteen or twenty years ago. However, their opportunity finally came to make a thorough study of industrial wastes and industrial waste disposal, in connection with the Ohio River Pollution Survey, authorized by Congress several years ago. The results of these studies are published in a photoprinted volume of some 319 pages, which includes detailed reports on eleven types of industry, comprising the major industries in the Ohio River Valley.

The types of plants and population equivalents are as follows:

Industry	No. of Plants	Pop. Equivalent	Pages
Brewing	38	264,300	12
By-Product Coke	23	745,200	35
Canning	218	758,900	42
Chemical	65	1,880,400	22*
Distilling	67	1,009,700	24
Meat	173	385,700	27
Milk	253	85,100	35
Oil Refining	47	116,500	32
Paper	59	1,659,200	26
Steel	174	—	—
Tanning	32	269,600	21
Textile	122	335,100	32
Miscellaneous	333	160,300	—
Total	1,604	7,670,000	308
To Cincinnati Sewers	—	1,108,400	
To Municipal Sewers, Basin	—	1,195,900	
Total for Basin	—	9,974,300	

* Coal washing.

The tremendous importance of industrial wastes in the Ohio Basin is shown by this impressive total.

The eleven guides are carefully prepared reports on all available information, including published literature, private investigation of unpublished data, sampling and inspection by the U. S. P. H. S. force, and previous data in the U. S. P. H. S. files. The guides give descriptions and flow sheets of each process, raw materials and products, sources and quantities of wastes, character of wastes, pollution effects, remedial measures, bibliography, note-taking forms, and inspection reports. After unit loss quantities were established for representative plants in each category, total losses for this category were pro-rated on the basis of raw materials, products, or employees.

The unique and valuable feature of this handbook lies in the care with which available data have been sifted and evaluated in relation to reliability and adequacy. There are too many papers and reports on unit losses for various wastes based on gagings and sampling for only one day, or even for single grab samples. While such data may be of value for that particular survey, they should not be quoted with the same weight as surveys extending over a week or more. The U. S. P. H. S. guides have been prepared with due evaluation of the worth of available data, and this discriminating viewpoint lends unusual value to this handbook. It ought to be printed and sold for at least five dollars.

The personnel connected with the preparation of the guides totals twelve, under the administrative direction of H. R. Crohurst, Senior Sanitary Engineer. Immediate supervision fell to Senior Public Health Engineer M. LeBosquet, Jr., and Associate Public Health Engineer Samuel R. Weibel.

F. W. Mohlman

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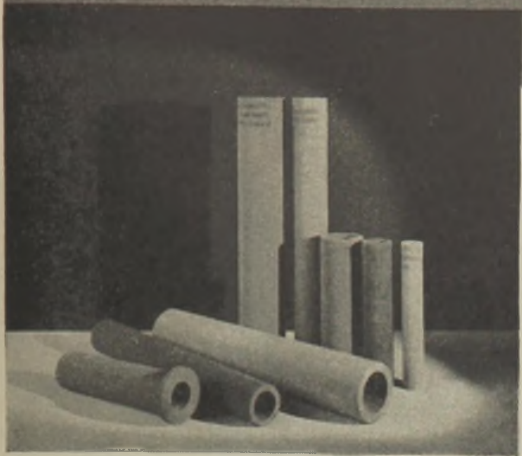
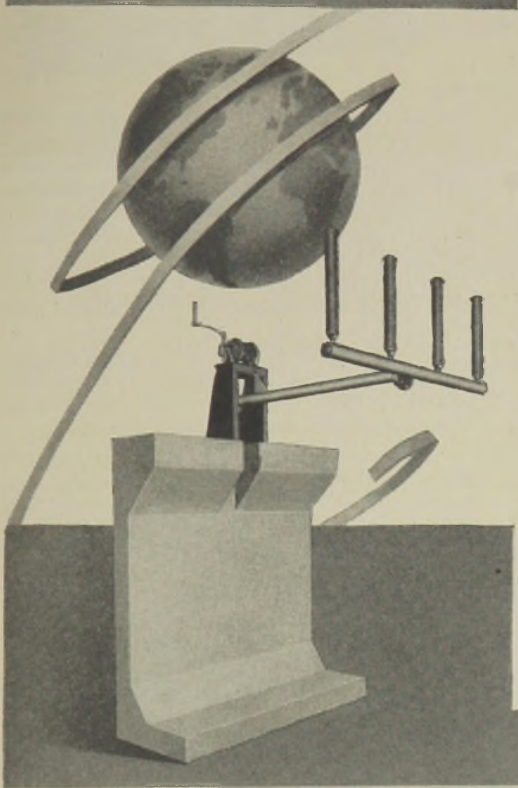
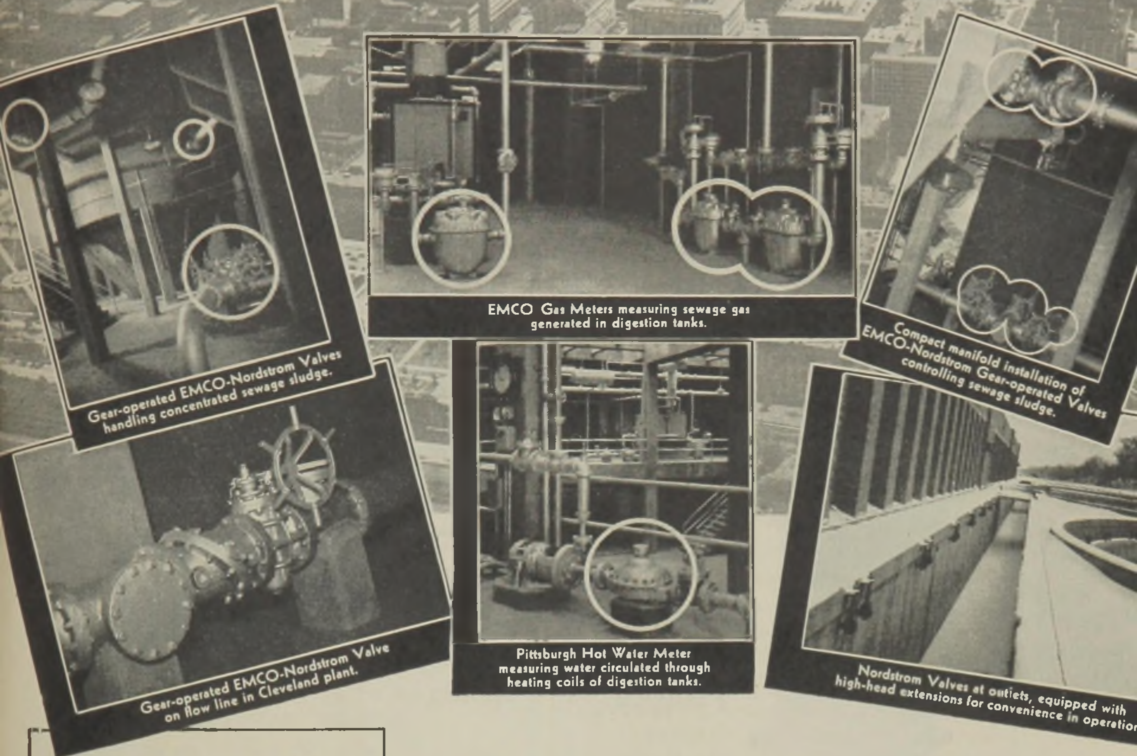




DIRECTORY OF ENGINEERS

In Cleveland, Ohio

SOUTHERLY and EASTERLY SEWAGE TREATMENT PLANTS



Gear-operated EMCO-Nordstrom Valves handling concentrated sewage sludge.

EMCO Gas Meters measuring sewage gas generated in digestion tanks.

Compact manifold installation of EMCO-Nordstrom Gear-operated Valves controlling sewage sludge.

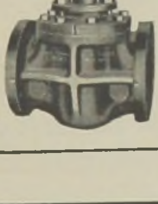
Gear-operated EMCO-Nordstrom Valve on flow line in Cleveland plant.

Pittsburgh Hot Water Meter measuring water circulated through heating coils of digestion tanks.

Nordstrom Valves at outlets, equipped with high-head extensions for convenience in operation.

EMCO Sewage Gas Meter

Pittsburgh Hot and Cold Water Meter



Nordstrom Lubricated Plug Valve

- **EMCO Sewage Gas Meters . . .**
- **PITTSBURGH Water Meters . . .**
- **NORDSTROM Lubricated Plug Valves**

CLEVELAND, Ohio, host city to the 1942 Wartime Conference and Third Annual Convention of the Federation of Sewage Works Associations, has in its Southerly and Easterly Sewage Treatment Plants many interesting applications of EMCO Sewage Gas Meters, Pittsburgh Water Meters and Nordstrom Valves.

In these plants EMCO Sewage Gas Meters measure the gas flow from the digestion tanks, account for the gas wasted and record the gas utilized in water heaters and incinerators. Pittsburgh Water Meters measure the heated water circulated through the coils of the digestion tanks. Nordstrom Lubricated Plug Valves provide the necessary controls on sewage sludge lines.

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Season's Greetings!

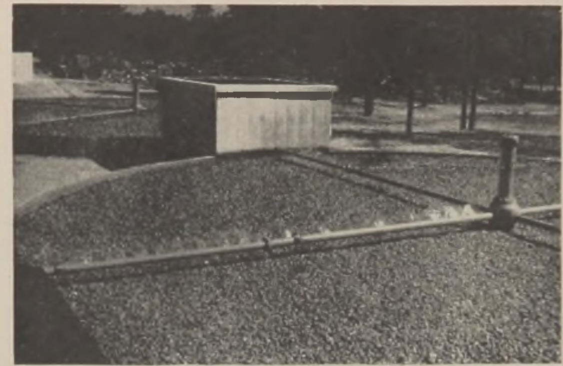
With the approach of the Holiday Season, we wish to take this opportunity on behalf of the Federation of Sewage Works Associations and its publication, SEWAGE WORKS JOURNAL, to thank all our members, subscribers, advertisers and friends for their past patronage and cooperation, and of wishing everyone:

A Merry Christmas

A Happy, Prosperous and Peaceful New Year

May we have the privilege of serving you again in 1943.

ARTHUR S. BEDELL, *President*
GEORGE J. SCHROEPFER, *President-Elect*
Federation of Sewage Works Associations



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