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A CIVIL ENGINEER'S COMMENTS ON PLANNING

PRESIDENTIAL ADDRESS BY ATHOLE B. EDWARDS, BOSTON SOCIETY OF CIVIL ENGINEERS, MARCH 17, 1943.

THESE comments regarding a few of the headaches of the planning engineer, along with some other matters, are offered the members of this society with the hope that you as civil engineers and as citizens, may give aid to the planning engineer in the solution of some of his problems.

When George Washington and his fellow workers pioneered in civil engineering, the one objective was to open this continent to settlers. They were laying the foundations for a nation.

The machine era started the crowding of our citizens into towns, cities and metropolitan regions thereby creating new problems.

As industry developed the producer of raw materials had to reach his markets in the industrial centers, and the manufacturer encountered the problem of getting his finished product to the buyers wherever they might be located.

Along with the moving of raw material and finished products, came the development of water supply, disposal of wastes, land use, plant location, housing, recreation and all other elements entering into modern conditions.

With such developments coming along the civil engineer enlarged his activities so as to deal with new conditions, and thus became a pioneer in what we call planning. He has cooperated with our friends in all other professions as well as with citizens in general.

Instead of attempting a survey of the huge realm of civil engineering as it has to do with planning, let us consider some phases of ground transportation.

Our engineering forefathers were not concerned with the refinements that are considered so essential today. A single lane highway or a one track railroad kept them busy, whereas we are studying plans for 12 to 16 lane limited access, super highways, and at the same time we are considering the merits of cul-de-sac developments for residential areas.

In the olden days our predecessors in the field of civil engineering planned railroads and highways in chunks of several hundreds of miles, and in the case of railroads especially, there was considerable strife, physical and otherwise, among competing surveys to spend the savings of thrifty New Englanders. One of their pastimes was to swing their lines so as to cross a competitor at an angle of about one degree. Some light rail and something to serve as ties were placed at the intersections and a push car was run over the rail to constitute a legal crossing. Then it was up to the other line, now the junior, to furnish, install and maintain the permanent equipment.

As regards the actual location survey, a buck board hauled by mules, the transit man on the front seat with his transit in his lap, the head flagman dangling his feet over the tail board with a pile of tooth pick stakes at his side, the link chain tied to the rear axle, the rear flagman a-horse-back giving the high sign as the chain passed a stake so that the head flagman could cut a notch on his tally stick; this accounted for the transit party. The levelman and the rodman operated on horseback, with turns of 1,000 ft. or more as the usual procedure. The outstanding friend of these pioneers was our old friend compensating error.

A planning engineer of today is not as crude as his predecessor. In the realm of railroad engineering the intricate problems of operating grades and curvature and the innumerable details of terminal layouts, put this form of planning close to exact science.

In highway matters the planning engineer may saunter through the countryside, on foot or at thirty five miles an hour, or he may count traffic at Kenmore Square for an hour. But before his report is filed he has gone into all phases of his problem from an origin and destination count of motor vehicles, to the chances of not having the legislative committee report "no legislation necessary".

The planning engineers like all other civic minded citizens, have their headaches, not due entirely to the other fellow. As he is working for and with human beings this is to be expected. One headache is the statesman, sometimes called the politician. This gentleman is an important factor in our democracy, we cannot get along without him, but nevertheless he has caused the planning engineer many sleepless nights.

Some, not all, of our politicians seem to believe that the sole object of their existence is to sow huge appropriations of the taxpayers' hard earned money broadcast throughout their districts with the hope that they may raise a fine crop of voters for their re-election. That procedure may be inevitable in a democracy, but the planning engineer can be of great assistance to the politician by planning the political farm so that the crops will be of lasting value both politically and otherwise, especially otherwise. The politician, in turn, can help both himself and the planning engineer, and incidentally the taxpayer. By comparing notes they can get legislation in shape so that the chances of getting by the legislative watch dogs of public funds will be greatly increased. The late Mr. Franklin Pillsbury, Project Engineer of the State Department of Public Works, was an outstanding example of a planning engineer who had the complete confidence of the politician.

One other headache for the planning engineer is the real estate holder, more especially the option holder. This guardian of property rights condemns as super-radical the policy followed in Great Britain of allowing no compensation for structures unfit for human use. Instead our option holder insists that any property with or without improvements that may be taxed at one cent a foot today, immediately increases in value to one dollar a foot as soon as the planning engineer saunters through the neighborhood. Aided and abetted by his legalistic bodyguard, who are armed with at least 30 recorded definitions of the term VALUE, he endeavors, often with success, to convince a jury of his fellow citizens that his property, held under a short option, before any new highway or street widening comes into being, has a greater value than a liberal estimate of the value after the improvement has been made. This would seem as if the taxpayer were paying double.

This problem is much the same as that encountered by the railroad claim agent who is called on to settle the claim involving scrawny livestock crossed with a locomotive.

Turning again to this versatile term VALUE, it may be corralled in this comment of Professor James C. Bonbright, of Columbia University: "Aware of the harm done by this highly ambiguous word, with its dangerously emotional content, some of the most analytically minded experts prefer to devitalize it by denying it any significance whatever, save as a name for any quantitative statement about property to which the dollar sign is attached."

To settle this problem of value that seems to be bogged down in the morass of expediency, perhaps one or both of the following proposals might do the job. Instead of answering the tax assessor's prayer by using condemnation awards as taxable valuations, why not give the planning engineer a break by using tax valuations for condemnation awards. Another proposal not likely to be adopted, is to have all planning engineers equipped with well organized arson squads.

Only those who are lacking in vision will concede that we are going back to the horse and oxen days. During the lives of most of us development in ground transportation will make our present facilities seem as antique as the horse and oxen days seem to us now. These will, of course, be supplemented by other means of transportation that exist today and are sure to be improved as time goes on.

The occasional transcontinental tourist will get along nicely for a long time to come except when he tries to get into or around the hubs of metropolitan regions. Then he as well as the planning engineer has his headaches. The latter may well put this problem at the head of his priority list. The preservation of areas where human activities are concentrated as contrasted with limited or unlimited decentralization will be ammunition for a war of words as long as, if not longer than it will take the city of Boston to get a real building code. There is a close relationship between these matters.

To write off the enormous investments that have been made in the public utilities and private developments as they exist today in the hubs of our metropolitan regions, using as a smoke screen the much abused word obsolescence, seems as rational as it would be to follow the recommendation of a gentleman mentioned above who opposed a meagre appropriation to reproduce by the photostatic process some maps that were deteriorating rapidly. He suggested that nothing be done to preserve these records but give the boys jobs to make new ones. That is, of course, debatable.

These rambling comments, facetious and otherwise, are offered to the members of this society with the hope that they will increase their interest in the welfare of their fellow man by means of their engineering talents.

Anyone who has established himself in the realm of civil engineering can invade the not exclusive domain of planning if he keeps his feet on the ground, is gifted with a sense of humor, is persistent, and is wise selecting whose toes to step on and when.

ENGINEERING EDUCATION — YESTERDAY, TODAY, AND TOMORROW

(Presented at the Annual Meeting of the Boston Society of Civil Engineers held on March 17, 1943.)

BY WILLIAM C. WHITE*

I. IN RETROSPECT

FOR nearly a quarter of a century—until December 7, 1941—engineering schools in the United States had concerned themselves with the task of educating for professional work in the several branches of engineering the young men of a country in whose future war was to have played no part. The first so-called World War had been fought and won, after an enormous expenditure of goods and services and an appalling cost in human suffering and in human life.

It seems only yesterday that we were rejoicing over the glorious prospect of a permanent peace. There was a general belief among our countrymen that the evil of military aggression had finally been suppressed and that the dawn of a warless world was breaking. Particularly was this true in the colleges. Neither faculties nor students were interested in establishing or maintaining any military tradition. R.O.T.C. units tended to become optional rather than compulsory and some were discontinued altogether. International relations clubs and model Leagues of Nations claimed far greater interest among our ablest students.

We hailed with acclaim the Washington Naval Treaties of 1921-1922, the Kellogg-Briand Pact of Paris outlawing war as an instrument of national policy in 1928, and the long awaited Disarmament Conference held during the early 1930's. Peace societies struggled valiantly to bring about better international understanding and to win popular support for world disarmament. To be sure there were disturbing signs on the horizon: Japan's activities in Manchuria and Italy's unprovoked invasion of Ethiopia and the rise to power of an unprincipled fanatic in Germany. But these all seemed so remote, so unlikely to touch our shores, and whatever happened elsewhere in

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the world we had determined not to become involved in another war anyway.

If a will to peace could have kept us out of war we certainly would have been safe. Our great unitary educational system presented a solid peace front. Engineering education was no exception. Our eyes were focussed upon the nation's internal problems, on the importance of improving the character and quality of engineering instruction to the end that our graduates might make a more fruitful contribution to the industrial life of this great country and to the enhancement of their profession. The interim between the first World War and the present conflict was marked by vigorous activity and noteworthy progress in the field of engineering education.

During the middle twenties our engineering schools co-operated with the S.P.E.E. in a comprehensive and exhaustive study of the whole field of their endeavors. The Carnegie Corporation provided the necessary funds. Dr. William E. Wickenden, now president of the Case School of Applied Science, gave able leadership and direction to the project, and the faculties of engineering institutions throughout the country threw themselves earnestly into a consideration of the data and reports that were developed. Every aspect of engineering education was carefully probed and scrutinized: quality of entering students, adequacy of faculties, effectiveness of teaching methods, soundness of curricula, costs, success of graduates and opinions of industrial leaders.

There is no question but that the effect of this investigation was both far reaching and fruitful. No new big transforming idea was discovered, no startling revelations issued from the studies to indicate that radical changes were in order, for engineering education appeared to be fundamentally sound. What was of great value, however, was the stimulus given by this investigation to each individual engineering school to take stock of its own situation in the light of national norms and to strengthen obvious weaknesses in its program. Of course all of our thinking was done in terms of a peace-time situation. Some of the ideas to which we were committed a decade ago as a result of this survey now seem dreamlike and remote in the face of what has actually come to pass.

So far as curriculum was concerned there was general agreement that more time and emphasis should be given to the humanistic and cultural studies to the end that our engineering graduates be equipped with greater social understanding and better prepared to assume their places in cultivated society. There was even considerable talk about lengthening the curriculum to five years from the traditional four to make room for liberal electives.

Early specialization was to be avoided—engineering education was to be broadened and enriched while retaining a dominant emphasis upon thorough grounding in the basic sciences. We aspired to truly professional status for engineers of the future and earnestly planned programs of instruction designed to acquaint our students with the cultural aspects of the nation's heritage as well as with the knowledges, skills, and disciplines of engineering.

Much attention was given to problems of vocational guidance and placement. During the 1930's engineers were a "dime a dozen" as many of you civil engineers in particular can recall. The basic difficulty was economic—there just were not engineering jobs enough to employ the available engineers plus those who were being graduated from our colleges—but since it was not in our power to do anything about the fundamental problem of getting industry back on its feet, we tried to alleviate the distress of our students by assuring them that there was plenty of room at the top and by teaching them all the tricks we knew that would be of advantage to them in getting a job. Obviously this merely served to enhance the prospects of some candidates over those of others and there were still a lot of capable engineers without work so that after a while we began to wonder whether we ought not drastically to curtail the enrollments in our engineering schools. Fortunately, from our present vantage point, the business cycle began an upward swing before this happened.

Another trend of the profession during the interval between wars was the rapid growth of the engineering licensure movement. In all but two or three states laws were enacted giving legal status to the professional engineer through registration and licensure. There was a growing consciousness that engineers of all branches ought to stand together shoulder to shoulder as members of a single great profession. Our national societies flourished and extended their scope and influence. Student chapters were established in the engineering colleges and there was a general awakening and resurgence throughout the whole field of engineering.

Out of this period of intense activity and sustained effort to improve engineering education there evolved a larger movement whose purpose was to enhance the status of the professional engineer. Most of you are familiar with the aims and achievements of the Engineers' Council for Professional Development, the national conference of engineering bodies, which, I think it is fair to say, resulted directly from the stimulus given the engineering fraternity by the Wickenden Survey of the middle twenties. As many of you know, E.C.P.D. is comprised of representatives of the five founder societies, the S.P.E.E., the N.C.S. B.E.E., and the Engineering Institute of Canada. Through its several committees E.C.P.D. has undertaken to accredit engineering curricula, to aid in student selection and guidance, to assist the development of the young engineering graduate, and to plan for suitable means of professional recognition. E.C.P.D. represents, in a sense, the culmination of two decades of constructive effort to co ordinate and harmonize the various aspects of engineering. We are indeed fortunate in this great war emergency in which engineering plays so vital a part to have such a powerful, unifying influence at work in the national interest.

II. Today

So much for yesterday! What of today? Let us take stock of the engineering scene of which we are now a part. It assuredly does not resemble the future we planned for a few years ago. Here are some of its salient features:

1. Engineering curricula have been accelerated and foreshortened instead of lengthened.
2. The humanistic and cultural stem has been reduced to make room for technical courses of immediate value in the war effort.
3. Engineering faculties have been diminished through losses to the armed forces and teachers that are left are carrying extreme overloads in an attempt to meet the tremendously increased demand for engineering instruction.
4. The facilities of our engineering schools are strained to the very limit to accommodate trainees for the military services and for industry. The Army and Navy alone would like to preempt 150% of the capacity of all engineering institutions in the country, if that were possible.
5. The federal government has appropriated $30,000,000 for the current fiscal year for supplementary technical courses at the college level conducted largely by engineering institutions under the E.S.M.W.T. program. This happens to be just about the same sum of money that was spent in one year to operate all of the engineering schools in the United States at the time of the Wickenden

Survey. Incidentally, this $30,000,000 represents only a small fraction of what Uncle Sam is spending this year for technical training to support the war industries. Another $160,000,000 is allocated to agencies at the vocational level and this does not include Army and Navy training programs for military personnel. Taken together, federal government appropriations for industrial war training alone this year exceed $200,000,000.

6. We have enlarged our classes, eliminated electives, suspended refinements such as honors plans, and generally streamlined our procedures so as to accommodate as many students as possible with the staff and facilities at our disposal.

The total engineering scene is, of course, a confused one in common with all other aspects of our national life under the stress of war. The Army and Navy have finally worked out specialized training programs suitable for their respective needs and purposes. A committee of nine comprising three representatives each from the Army and Navy and the War Manpower Commission has allocated the available engineering schools between the two services and arrangements are now being worked out whereby substantial numbers of young men will be given engineering training for military purposes in uniform and at government expense.

The source of supply of engineering talent for war industries, however, is not so clear. It is generally agreed among those responsible for the prosecution of the war that industry must have an adequate supply of technical personnel as well as a suitable flow of material if production is to be increased to the required extent. There is as yet no agreement as to how this necessary civilian engineering personnel is to be obtained. Various proposals to insure the training of engineers for industry have been considered by the War Manpower Commission but so far as I know none of these has been acceptable to that body. Principal difficulty seems to lie in finding a satisfactory way in which to select and finance the young men to be trained for industrial responsibilities in competition with the Army and Navy.

Meanwhile the tremendous demand for technically trained men and women in war production is being met, in part at least, through the E.S.M.W.T. program that I have mentioned. Many of you already know more or less about E.S.M.W.T. but I think all of you may be interested in a very brief summary of its purpose and program.

Originally sponsored by the U. S. Office of Education at the suggestion of a group of leading engineering educators who foresaw two and a half years ago that there would be a serious shortage of technically trained people as the defense program developed, E.D.T. as it was first called, was designed to provide short, intensive courses at the college level to fit men and women for technical jobs in war industries. At first limited to engineering, the program was later broadened to include chemistry, physics, and production supervision and the title was changed to Engineering, Science, and Management War Training. Over 200 colleges and universities throughout the country are now participating in this program which has now become one of the six components of the W.M.C.'s Bureau of Training.

Two features of E.S.M.W.T. differentiate it from other government training programs and are worthy of note. First is the voluntary nature of the operating plan and second the effective decentralization that has been achieved. Eligible institutions were invited to co-operate on a non-profit basis, to determine locally the actual needs of industry for college level technical training, to propose suitable courses to meet these needs, and to assist in placing the trainees where they would be of greatest use to the war effort. The program is co-ordinated regionally by committees comprised of a representative from each participating institution under the chairmanship of an unpaid part-time regional adviser. There is no paid hierarchy of administrators and supervisors who might tend to expand the program for its own sake. Each college deals directly with Washington headquarters where a small full-time staff—most of whom are on leave of absence from engineering school faculties—administer the plan with notable efficiency under the direction of Dean George W. Case of the University of New Hampshire College of Technology.

While the courses offered are all of college grade they are not traditional units of engineering curricula but are tailor-made to meet the specific requirements of particular jobs that industry needs to fill. The plan is flexible enough to provide for training in basic mathematics and mechanical drawing at one extreme and control of soils in airport construction and advanced timber design at the other. Some 12,000 short courses of college grade will be offered under E.S.M.W.T. this year enrolling over 600,000 trainees.

Greater Boston institutions: Harvard, M.I.T., Tufts, Boston College, Boston University, Northeastern, Simmons, and Wellesley have co-operated magnificently in meeting the demand for special technical training at the college level in this area. Most of the courses are offered in the evening for people who are already employed but who need additional specialized training to enhance their usefulness in war production. Other courses are of the full-time pre-employment type to prepare new workers to replace those who are called to military service. Constantly increasing numbers of women are being trained in courses of both types. Industry can absorb a large number of women assistants to engineers, trained through E.S.M.W.T. in basic mathematics, mechanics, drawing, and production processes. Through orientation courses in military map making, E.S.M.W.T. is training several hundred senior girls in women's colleges for after graduation positions with the Army Map Service in Washington. Further in-service training will be given these girls after they are placed on the job.

In short, engineering educational resources today are being exploited to their utmost limits, but the ideal of yesterday for *broad engineering education* has of necessity given way to the imperative of today for relatively narrow and specific *engineering training*.

III. Tomorrow

To recapitulate the gains of yesterday and to survey the activities of today in engineering education are routine tasks. It takes no great stretch of the imagination either to foresee that the demand for engineering training will continue to be extremely heavy throughout the war. But to forecast the post-war trends of tomorrow is, in contrast, an assignment beyond the scope of any mortal mind. It would be presumptuous of me to attempt any prophecy of the educational scene as it will exist in that uncertain tomorrow when the Axis powers have been vanquished and the task of rebuilding the world can begin. All I can do is to state briefly some of the factors that will have to be reckoned with and express my opinion as to their influence upon engineering education.

First of all, it seems evident that we shall have after the war a tremendous number of partially trained technical personnel, both men and women; people who have been taught a single skill or a narrow range of skills serviceable to the war effort. These people will not be readily employable in other capacities in peacetime industry. Many of them think of themselves as engineers, however, and they will aspire to professional development. During the war they will have been earning relatively large incomes and will have come to regard themselves as part of the engineering profession.

In addition there will be a great many young men returning to civil life from military service who have had varying degrees of technical preparation and who will be desirous of finding employment in the several branches of engineering. Government spokesmen indicate that the flow of soldiers back into civilian pursuits will be much more gradual than it was after the last war, not only because of geographical reasons but also because we shall need to retain a substantial standing army and because it would be economically suicidal to effect an immediate and wholesale demobilization. Nevertheless, there will still be a sizeable number of technically trained men from the armed forces to be assimilated.

Add to these the casualties—physically incapacitated men for whom the nation will have an obvious and primary responsibility for rehabilitating vocationally—and the total mounts impressively. What are we going to do with this huge force of specialized technical personnel after the war is over? Are we destined for another period of widespread technological unemployment, perhaps on an even larger scale than in 1932? Will engineers be a "dime a dozen" again? Or can we hope for a more acceptable post-war development? Let me defer this question for a moment while I remind you of the economic situation we shall probably face when the military phase of the present conflict is over.

It is estimated that the United States by that time will have a national debt of between $250,000,000,000 and $300,000,000,000. Obviously, if we are to carry this huge debt and maintain the standard of living that we want—well above the bare subsistence level—we must create new wealth in such abundance as to make the service charges on the debt a relatively small factor in the national income. Can we step up our national income from this year's estimated $125,000,000,000 to $150,000,000,000 or more, without inflation, and accomplish this? Who knows? But we must try, anyway, for the alternatives are not pleasant to contemplate. We don't want to repudiate the debt, or pay it off with greatly depreciated money, or get along on the bare subsistence level that would be necessary if we pay it off the hard way as a substantial service charge upon a national income of pre-war size.

It is therefore extremely heartening to note the thought and effort that is already being given to post-war economic problems by business men, educators, and government leaders. The New England Council

Bulletin for February reports a recent conference at the Harvard Business School of 250 business men who met to consider this question: "What will we do when V-day arrives?" These men are already planning how they can begin immediate production for peacetime consumption as soon as the war is over.

Some of you may have seen that cartoon in one of our periodicals a short time ago depicting a shell loading plant with the shell cases moving along a belt conveyor. The plant superintendent showing a visitor the operations is pointing to a device whereby lamp shades could be dropped upon the shells as they move by and the caption under the cartoon reads: "On V-day I'm going to pull this switch."

The transition implied in this cartoon—while far from being as simple as depicted—is nevertheless the goal toward which a great many industrialists are striving today, even in the throes of an all-out war effort. Some of the larger companies have small but competent staffs engaged in planning their immediate post-war operations. Surely this is a sensible and indeed an essential addition to our war effort.

There is increasing realization, too, that winning the war in itself will solve no problems. Winning the war will merely make it possible to begin solving some of the problems that we have been wrestling with previously and that will be there still to plague us: problems of international relations; unemployment; racial discrimination; social security, and all the rest. We must tackle them again, and do a better job this time.

Writing in the March issue of *Mechanical Engineering* on post-war industrial development, George A. Sloan concludes that "When the war ends, we shall have an expanded and modernized industrial plant manned by an enlarged, skilled labor force under the direction of men fresh from performing the miracles of war production. All of the elements will be present, therefore, for our entrance into a period of sustained prosperity. In order to achieve a high level of production and employment, however, we will need a vigorously expanding private enterprise."

Mr. Sloan's prediction seems reasonable except that I think we shall need to guard against the probable tendency to let down when the military phase of our struggle has been completed. People are working feverishly under the stress of war. Whole families are employed where formerly one bread winner served the group. Long hours of overtime are common and on the whole cheerfully accepted.

Now when the guns stop firing and the pressure for more and more war production is released there will be a natural tendency to relax, to want to return to a more leisurely life. There will be a demand for shorter hours, less arduous schedules, and it won't seem such a good idea for everybody in the family to be in the labor market. Travel and golf and fishing and social activities will all seem mighty apealing and it won't be easy to resist the temptation to spend as much time as possible in their enjoyment. But time spent that way will not produce new wealth and will not increase the national income—and thus will not enable us to dwarf that huge debt we will have acquired.

We will need not only to keep our present labor force busy but also add to it the returning soldiers if we really want to produce this abundance of new wealth that is to be our salvation. As I look ahead I see no surcease in our labors at the war's end. I think rather that we shall need to rally ourselves and our associates for even greater effort than we are expending now. I suspect that we shall look back upon the present hectic days some years hence and reflect "My, my—and we thought that was tough."

Engineers particularly will be called upon to bear new burdens. For it is the engineer who must rebuild a broken world—repair its highways, reconstruct its battered cities, reestablish its bombed bridges, convert its armament factories to civilized purposes, create new products and design the machinery and the processes that will enable their manufacture. All this means more work, not less. There can be no "peace in our time" if I may paraphrase Mr. Chamberlain's pathetic message and use the word "peace" to mean a life of ease and comfort free from arduous tasks.

To return now to the question of what we are to do with that great supply of partially trained technical workers we shall have available after the war. We shall have to provide them, of course, with further training for the arts of peace. Perhaps a continuation of the E.S.M.W.T. program in reverse—an E.S.M.P.T.—will be needed for this purpose.

But along with this job of retraining for peacetime vocations we shall have the immeasurably more difficult task of reorganizing and renewing those kinds of education that really make life worth the living. I say this is a more difficult task because it is so much less clearly defined and so much more complex than is the problem of training for specific jobs. Furthermore we shall probably come through this war with strongly developed and improved processes of technical instruction but our programs of liberal education will have been pretty well shot to pieces.

Yet we must find ways of reviving them and of increasing their significance and value to larger numbers of our population, not only college boys and girls, but adults as well. For in the liberal arts and sciences lie our hopes of learning how to think and act in ways that will contribute toward a better and happier world. Every sign points to the prospect that engineers will be increasingly influential in our post-war civilization. But their technical genius and skill alone will not be enough. They must also be equipped with the moral stamina, the ethical judgment, and the breadth of vision necessary to guide that professional skill in the direction it should go.

What a ghastly paradox it is that all the scientific and engineering genius of the world should be partitioned into two camps each working with might and main to destroy the other. We mustn't let it happen again! That's exactly what was said after the first World War, but we fumbled our opportunity. This time we must not abdicate our responsibilities but take our full part in the establishment and maintenance of a world order.

So I say to you, members of the oldest engineering society in these United States, gird yourselves for still greater endeavors when the war is won. Let there be no selfish return to "normalcy" such as characterized our previous post-war policy. There is no hope for a better world in that.

The January number of *Wartime Engineering* issued by the Westinghouse Company carried on its back cover a quotation from an essay by Thomas Paine published in the stirring days of 1777. It seems to me a fitting one with which to bring my remarks to a close:

"Those who expect to reap the blessings of freedom, must, like men, undergo the fatigue of supporting it."

SLOPING CHORD OPEN PANEL FRAMES BY MOMENT DISTRIBUTION METHOD

By Frederic N. Weaver, Member*

(Presented at a meeting of the Designers Section of the Boston Society of Civil Engineers held on October 14, 1942.)

One important group of structures consists of rigid frames with open panels and inclined chords: viaducts, towers, bents, Vierendeel trusses, etc. While the Vierendeel truss is of questionable economic value as a bridge truss, the open panel with inclined chords is widely used in various bents where diagonal bracing may not be used. Various papers on this subject are available: a notable mathematical treatise has been written by Professor Dana Young;[1] and Professor L. C. Maugh has devised a simple and rapid solution, based upon the use of successive corrections, for frames with chords having the same moments of inertia.[2]

This paper will present a simple, practical method by which the ordinary procedures of moment distribution may be applied to the solution of this type of frame. The open panel with inclined chords differs from the rectangular frame in that the total shear across a panel is resisted not only by the shear or component of shear in the chords, but also by the component of axial stress in the inclined member. Thus, while the method is the familiar one of moment distribution: fixed end moments, distribution, carry-over, and correction for unbalanced shear, the correction for shear involves the proper component of inclined stress. Fixed end moments may be assigned to the chords, and fixed end moments in the webs computed from relative deformations; but in frames of more than one story convergence will be hastened by determining these moments from the assumption that all points of counterflexure are at mid-length, as indicated in Fig. 1, and discussed in full later.

With Fig. 2 are shown the relations between deflection and shear

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[1]Analysis of Vierendeel Trusses, Dana Young, Transactions, Am. Soc. C. E., Vol. 102, 1937, p. 869.

[2]The Analysis of Vierendeel Trusses by Successive Approximations: L. C. Maugh, Publications of the International Association of Bridge and Structural Engineers, Vol. 3, 1935.

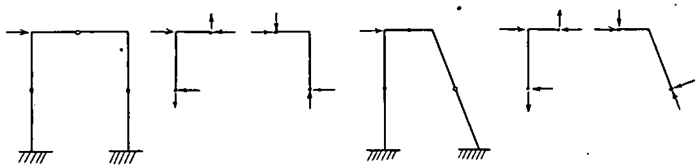


FIG. 1.

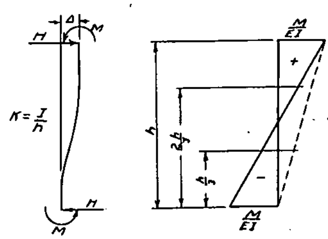


FIG. 2.

and moment in a prismatic beam deflected without rotation. In this sketch the signs are those usually employed: a positive moment causes compression in the upper fibers. Fig. 3 gives the sign convention em-

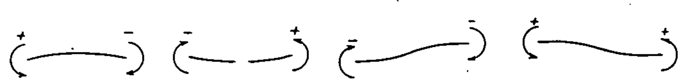


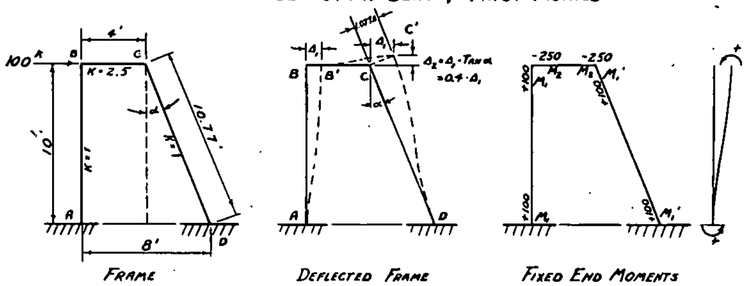
FIG. 3.

ployed for all further discussion in this paper. A moment which causes the *joint* to which the member is connected to rotate in a clockwise direction is a positive moment. With this convention, all carry-over factors are positive.

PRELIMINARY ILLUSTRATION

In Figs. 4, 5, 6, and accompanying text, is given, as illustration of some of the principles involved, the solution for a single bent with one inclined chord under the action of a lateral load. If the vertical member of the frame be given a displacement *B-B'*, then point *C* is displaced horizontally a like amount, and the inclined member *CD* is displaced to *C'D,* giving the relative displacements of the vertical, inclined member, and top horizontal, from which relative fixed end moments may be computed. An arbitrary fixed end moment may be assigned to each end of the vertical member, thus giving the fixed end moments at the ends of the other members. Distribution and carry-over follow

Single Story Bent, First Method



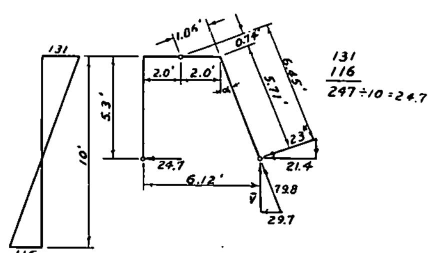
Assign Arbitrary Fixed End Moments of +100 To The Vertical Chord

Web Moment $\frac{\Delta_2}{\Delta_1} = \frac{\frac{M_2 h_2}{6EK_2}}{\frac{M_1 h_1}{6EK_1}} = \frac{M_2}{M_1}\cdot\frac{h_2}{h_1}\cdot\frac{K_1}{K_2}$

i.e., $\frac{a+\Delta_1}{\Delta_1} = \frac{M_2}{M_1}\cdot\frac{4}{10}\cdot\frac{1}{2.5}$, $M_2 = -2.50 M_1$

Also, $\frac{1.077\Delta}{\Delta} = \frac{M_1'}{M_1}\cdot\frac{10.77}{10}\cdot\frac{1}{1}$, $M_1' = M_1$

FIG. 4.



$23 \cdot \frac{6.45}{1.86} = 79.8$

$V \cdot \text{Tan}\,\alpha = 79.8 \cdot \frac{4}{10.77} = 29.7$

24.7
21.4
29.7
75.8 = Shear

Multiply Moments By $\frac{100}{75.8}$

= 173 Top
153 Bottom

FIG. 5.

in the usual way. When the joints are balanced, the points of counterflexure are found, the axial load in the inclined member found, and the shear acting across the panel found. In this case the shear is consistent with a load of 75.8 kips. The actual load is 100 kips, whereupon the actual moments are found by proportion.

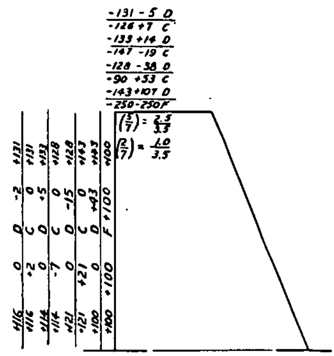


FIG. 6.

GENERAL METHOD

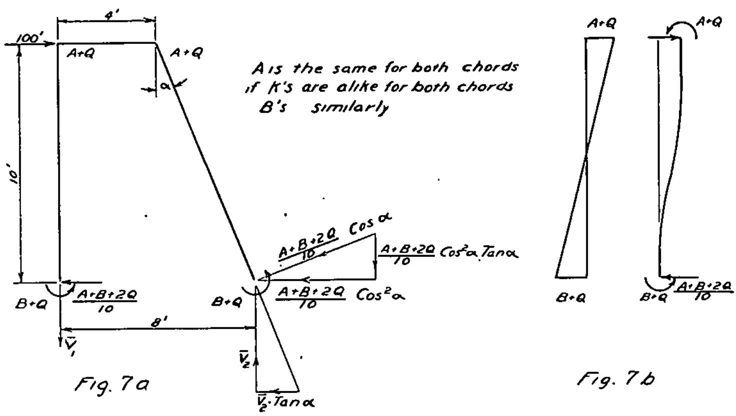
In frames of more than one panel, a single correction factor applied at the end of the solution will not correct for shear in all panels; thus shear correction at each cycle is necessary, and fixed end moments as indicated in Fig. 1 are desirable. At the end of the first carry-over step the proper shear correction is made, and another cycle started.

Shear correction, as developed in this paper, is similar to that employed in the solution of rectangular frames. At the end of the carry-over step the frame is considered to be locked, and the shear is corrected under this assumption. Then the frame is considered to be unlocked; that is, another distribution is made.

The shear correction for a given panel may be determined by solving for points of counterflexure, after the carry-over step, considering the portion of the structure at one side of the points of counterflexure as a free-body, determining the components of shears in the chords and components of stress in the inclined members, and computing the amounts of moment which must be added to the chords to balance the panel in shear, similar to the work under Figs. 4, 5, and 6. But this computation must be made for each cycle and for each panel. A much simpler method is as follows: Determine the amount of moment to be added to top and bottom of the chords to satisfy equilibrium in shear and moment, by finding an equation which will give this correction directly. Each equation will hold for each panel, no matter what the moments at the end of the carry-over step are, and corrections may be found immediately by substitution.

The theory of shear correction by this method is given under Fig. 7, which is the same problem as Fig. 4. To save the labor of

Derivation of Equation for Shear Correction.



Let A and B be the moments at the end of the carry-over step.

Let Q be the moment to be added top and bottom to bring the shear in the panel to 100, and to satisfy conditions of moment.

1. $\Sigma H=0 \qquad 100-\frac{A+B+2Q}{10}-\frac{A+B+2Q}{10}\times\cos^2\alpha-\bar V_2\times\tan\alpha=0$

2. $\Sigma M=0 \qquad 100\times10-2(B+Q)+8\times\frac{A+B+2Q}{10}\cos^2\alpha\cdot\tan\alpha-8\times\bar V_2=0$

Mult. #2 by $\frac{\tan\alpha}{8}$, *and subtract from #1, noting that* $\tan^2\alpha=\frac{\sin^2\alpha}{\cos^2\alpha}$, *that* $\sin^2\alpha+\cos^2\alpha=1$, *and that* $\tan\alpha=0.4$

$$100-50+\frac{2(B+Q)(0.4)}{8}-\frac{A+B+2Q}{10}-\frac{A+B+2Q}{10}=0$$

$$Q=167-\tfrac{2}{3}A-\tfrac{1}{3}B \quad \text{-------------} \quad (I)$$

FIGS. 7a AND 7b.

computing points of counterflexure, the entire panel is taken as the free-body. (The moments at the bottom ends of the chords must be written in the equations.) Two equations of equilibrium are written, from which the moment Q, the amount to be added to each end of each chord, is found. As general equations become somewhat lengthy, and as they have no particular advantage, the solution is given partly in general terms and partly in terms of the particular problem.

For this bent, Q is found to be $167—\frac{2}{3}A—\frac{1}{3}B$. The constant, in this case 167, will vary with the conditions. If the load be increased to 600 kips, the constant will be 1000. The coefficients of A and B will change if the dimensions of the panel are changed, but each equation will hold for the panel for which it was computed. Fixed end moments may be computed in the same way.

The solution, correcting for shear at each cycle, is given in Fig. 8.

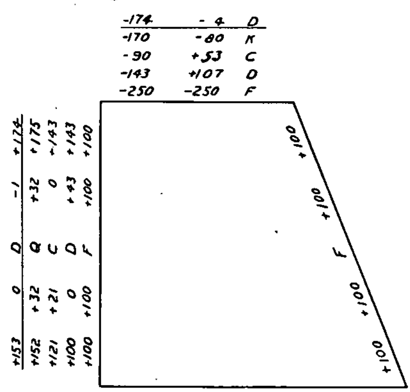


FIG. 8.

Fixed end moments, the first distribution, and the first carry-over step are the same as for Fig. 6. At this point a correction is made for shear. The equation is $Q=167—\frac{2}{3}A—\frac{1}{3}B$. For the first correction, $A=+143$, and $B=+121$. $Q=167—\frac{2}{3}(143)—\frac{1}{3}(121)=+32$. The first Q for the horizontal member is $—2.5M_1=—2.5(32)=—80$. When these values are added, the first cycle is completed. In this case, as the vertical and horizontal moments are equal at the end of the first cycle, the solution is complete in one cycle.[3]

FRAME WITH TWO PANELS

In Figs. 9 and 10 is shown a frame with two panels, with chords of differing inclinations. While arbitrary fixed end moments could be

[3]The arrangement of computations is taken from a paper presented before the Designers Section, B.S.C.E., April 13, 1932, "An Explanation of the Hardy Cross Method of Analysis of Continuous Frames," by Oliver G. Julian. Four columns of figures are written against each member. The inner rows give the change in moment for each step, and the outer rows give the total moment at each step.

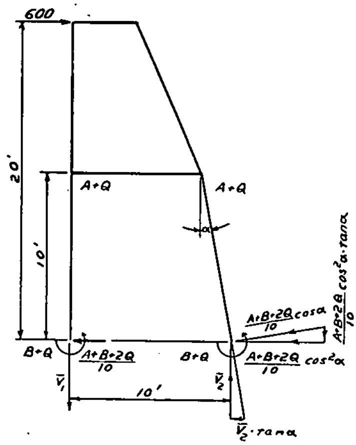


FIG. 9.

assigned to the chords and the resulting fixed end moments in the webs computed, convergence will be hastened by using fixed end moments having approximately the same relation to the loads on the frame. The work for the determination of all fixed end moments is shown in Fig. 10, the determination of shear corrections below, and the solution to three cycles in Fig. 11.

After the fixed end moments have been computed, distribution and carry-over follow in the usual manner, but now shear corrections must be made for two differing panels. In the upper panel, which is like Fig. 4 except for the load, the shear correction equation is

$$Q_1 = 1000 - \tfrac{2}{3}A - \tfrac{1}{3}B \qquad \text{(II)}$$

This may be found from the work leading to Equation I or from $600 \times 167/100 = 1000$.

For the lower panel, Fig. 9, the entire frame may be taken as the free-body, whereupon the equations of equilibrium are

1. $\Sigma H = 0.\quad 600 - \dfrac{A+B+2Q}{10} - \dfrac{(A+B+2Q)\cos^2\alpha}{10} - V_2 \,.\, \tan\alpha = 0$

2. $\Sigma M = 0.\quad 600 \times 20 - 2(B+Q) + \dfrac{10(A+B+2Q)\cos^2\alpha \,.\, \tan\alpha}{10}$

$-10\, V_2 = 0$

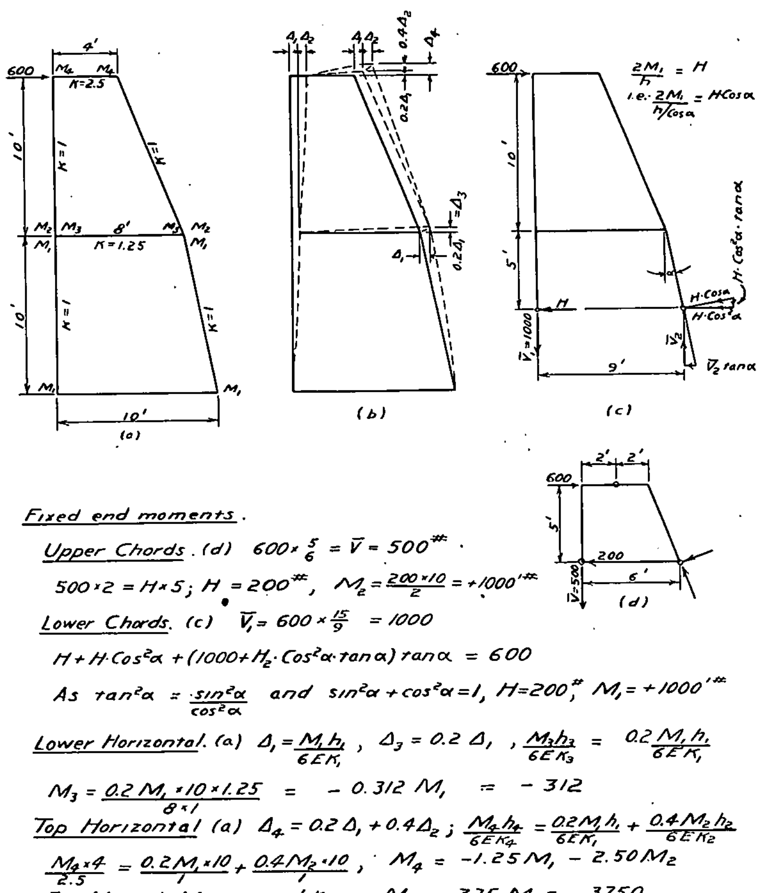


FIG. 10.

Mult. (2) by $\frac{\tan \alpha}{10}$ and subtract from (1), noting that $\tan \alpha = 0.2$

$$Q_2 = 1000 - \frac{5}{9} A - \frac{4}{9} B \tag{III}$$

With shear correction equations determined, the problem may be solved without further sketches. At the end of each carry-over step the corrections for shear are found from equations II and III. The

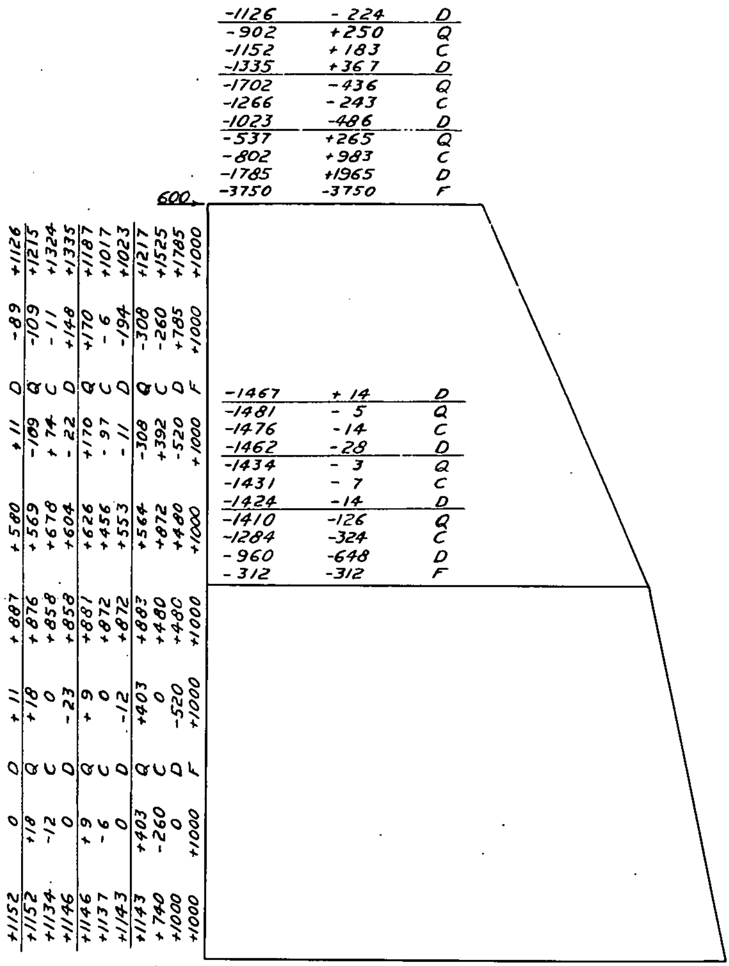


FIG. 11.

corrections for the lower horizontals are given by $Q = -0.312Q_2$ and the corrections for the upper horizontals by $Q = -1.25Q_2 - 2.50Q_1$.

The process is repeated until convergence is sufficiently close. If convergence is slow, the values at the end of the Q step and its adjoining D step may be plotted simultaneously, and the final values found with a good degree of accuracy from the graphs. In Fig. 12 a convergence diagram for the upper left hand corner is given. The information

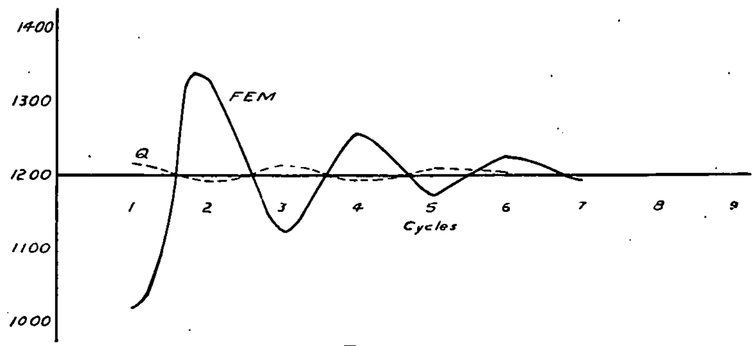


FIG. 12.

was plotted from values from six cycles, and indicate early, from the flatness of the Q curve, a final moment of about 1200. In fact, the moment, computed with considerable care, is 1206.

In Fig. 13 is shown the same frame, but with a load also at the

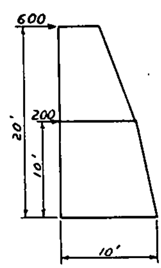


FIG. 13.

lower level. Fixed end moments and shear corrections are determined as before. The 200^k load must be written into the equations for shear and moment for the lower panel. The fixed end moments are as given in Fig. 14, and the shear correction equations are

Lower Panel. $Q_2 = 1444 - 5/9A - 4/9B$
Top Panel. $Q_1 = 1000 - \frac{2}{3}A - \frac{1}{3}B$
Lower Horiz. $Q = -0.312Q_2$
Top Horiz. $Q = -1.25Q_2 - 2.50Q_1$

The solution to three cycles is given in Fig. 14. The final moment in the upper left hand corner, after five cycles and a convergence diagram, is 1240.

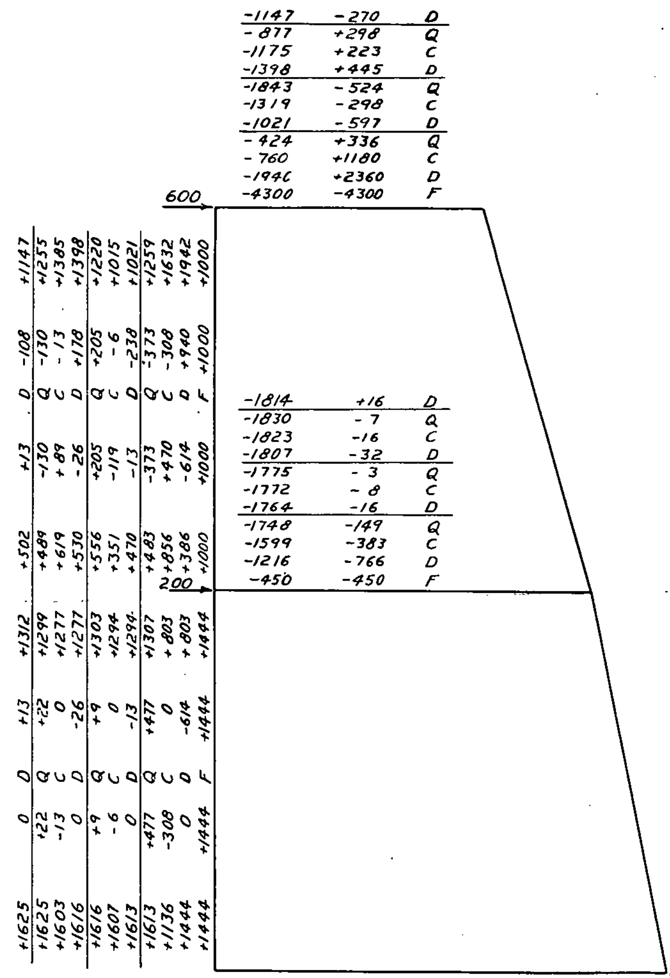


FIG. 14.

FRAME WITH BOTH CHORDS SLOPING

Fig. 15 shows the deformation of a frame with both chords sloping. From the equations with Figs. 2 and 4 the fixed end moment in the top horizontal is —2.50 times the fixed end moment in the chords, and the shear corrections bear the same ratio. Fig. 16 shows the method of obtaining fixed end moments, a method which may be

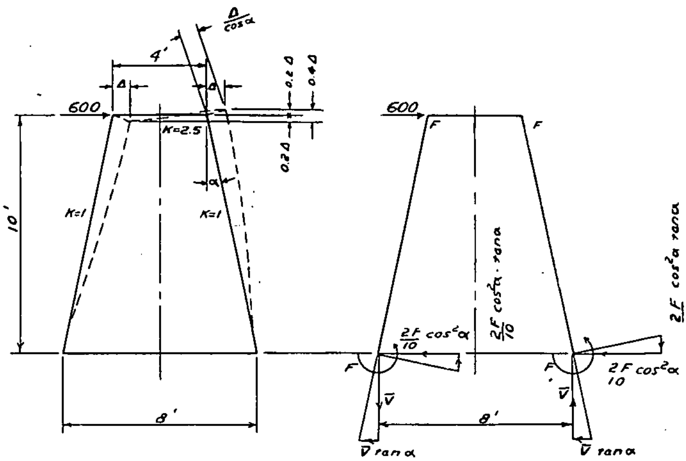


FIG. 15. FIG. 16.

applied to a tower with any number of panels. The portion above any horizontal is taken as the free-body, and the fixed end moment, F, determined from the equations of equilibrium. For the panel shown,

$$1.\ \ \Sigma H=0.\ \ 600 - 2 \times \frac{2F}{10} \cos^2 \alpha - 2V \ .\ \tan \alpha=0$$

$$2.\ \ \Sigma M=0.\ \ 600 \times 10 - 2F - 8V + 8 \times \frac{2F}{10} \cos^2 \alpha \ .\ \tan \alpha=0$$

Solving as before, $M=1000$

Shear Correction. Proceeding similarly, with A and B the moments at the carry-over step, and Q the amount of moment to be added top and bottom,

$$Q=1000-\tfrac{2}{3}A-\tfrac{1}{3}B$$

Because of the dimensions of the figure, the various values are the same as for the upper panel of Fig. 9.

FRAME WITH DIFFERING MOMENT OF INERTIA IN THE CHORDS

The frame shown in Fig. 17, having chords with differing moments of inertia, will deform as in Fig. 4. Hence the relative moments produced in the members by a unit deformation of the vertical chord will be given by

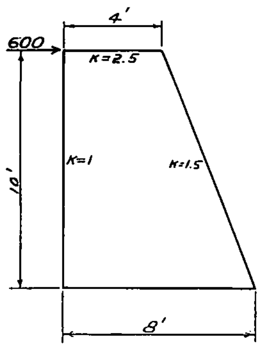


FIG. 17.

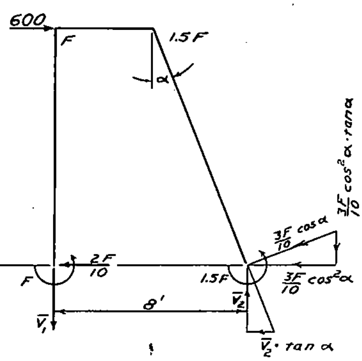


FIG. 18.

$$\frac{\Delta_1}{\Delta_2} = \frac{M_1 h_1 K_2}{M_2 h_2 K_1}, \text{ and } M_2 = \frac{\Delta_2}{\Delta_1} \cdot \frac{M_1 h_1 K_2}{h_2 K_1}$$

If M_1 is the moment in the vertical, and M_2 the moment in the inclined chord,

$$M_2 = \frac{\Delta_1}{\dfrac{\cos\alpha}{\Delta_1}} \cdot M_1 \frac{h_1}{\dfrac{h_1}{\cos\alpha}} \cdot \frac{K_2}{K_1} = M_1 \times \frac{10}{10} \times \frac{1.5}{1.0} = 1.5\ M_1$$

Similarly, the moment produced in the horizontal is $-2.50 M_1$.

If the fixed end moment in the vertical is called F, the fixed end moment in the inclined chord will be $1.5F$; and the method of finding fixed end moments, applicable to any number of bays, is similar to the following: (See Fig. 18)

1. $\Sigma H = 0.\quad 600 - \dfrac{2F}{10} - \dfrac{3F}{10} \cos^2 \alpha - V_2 \cdot \tan \alpha = 0$

2. $\Sigma M = 0.\quad 600 \times 10 - 2.5F + 8 \times \dfrac{3F}{10} \cos^2 \alpha \cdot \tan \alpha - 8V_2 = 0$

Solving, $F = 800$; $1.5F = 1200$; Horiz. $= -2000$

Shear Correction. Let A, B, C, and D be the moments in the chords at the end of the carry-over step, as indicated in Fig. 19. If Q is the correction to be applied to the vertical, then $1.5Q$ is the correction

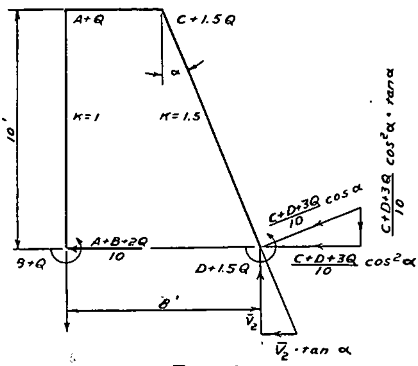


FIG. 19.

for the inclined chord, and —2.5Q the correction for the horizontal. From Fig. 19 there is obtained

$$1.\quad \Sigma H=0.\quad 600-\frac{A+B+2Q}{10}-\frac{C+D+3Q}{10}\cos^2\alpha - V_2 \,.\, \tan\alpha=0$$

$$2.\quad \Sigma M=0.\quad 600\times 10-(B+Q)-(D+1.5Q)$$

$$+\frac{8(C+D+3Q)}{10}\cos^2\alpha \,.\, \tan\alpha - 8 \,.\, V_2=0$$

$$\text{Solving, } Q=800-\frac{2}{15}(2A+B)-\frac{2}{15}(2C+D)$$

VIERENDEEL TRUSSES

Vierendeel trusses, such as that shown in Fig. 20, may be solved

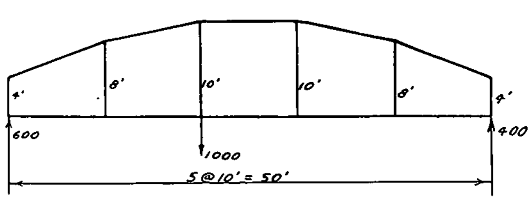


FIG. 20.

by finding fixed end moments for the portion to the left of the load and for the portion to the right of the load, as if both portions were fixed at a base line through the load. Shear correction equations are found similarly for all panels in the two portions. Distribution, however, is performed for the actual truss, both portions united.

Conclusion

There is no easy and rapid method of solving complicated frames. In the problem under discussion the complication arises from the inclined chords, which cause, on the one hand, the solution of a large number of simultaneous equations, or, on the other, the labor of solving by successive corrections. The method here presented has the advantage of allowing the designer to use familiar methods, which should result in a saving in time.

CRANSTON, RHODE ISLAND, BUILDS COMPLETE NEW SEWERAGE WORKS FOR 53,000 PEOPLE

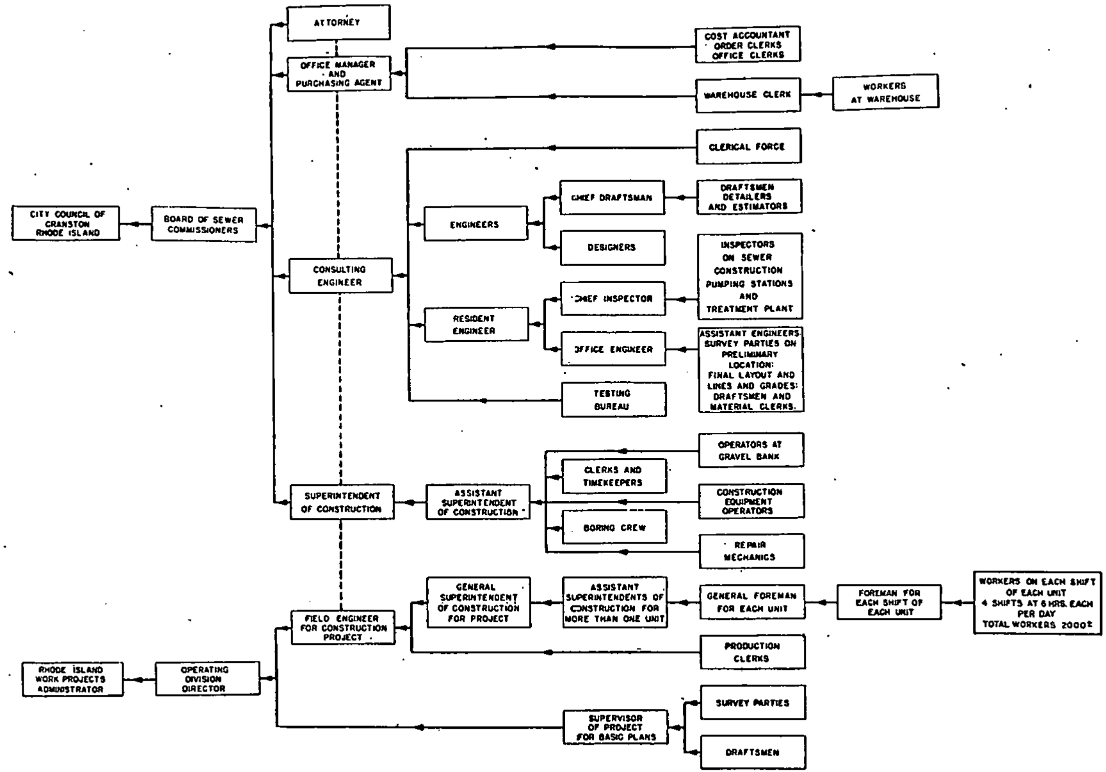
By Ralph W. Horne, Member*

Cranston is the largest suburb of Providence; it lies just south and southwest of that city. It extends from the west shore of upper Narragansett Bay inland nearly nine miles. The City covers about 29 square miles; it has about 250 miles of highways; in 1942 its taxable valuation was about $73,250,000 and its tax rate was $23.00 per $1,000 valuation. Its population is about 53,000.

Since 1923, serious consideration, from time to time, had been given to the matter of installing modern sewerage facilities but it was not until November 1938 that the project approached a reality. At that time, the Federal Government approved an application to the Work Projects Administration for the undertaking, and offered Federal assistance to the extent of about $3,500,000 toward the project, which was estimated to cost a total of nearly $6,000,000. Passage of enabling legislation by the Rhode Island General Assembly early in 1939 cleared the way for making an actual start. Construction work began June 5, 1939, with the W.P.A. organization and City forces working jointly on the project. It was one of the largest relief labor projects of its kind undertaken by the W.P.A.

The project was organized with the City providing practically all engineering services, both for designs and construction, and also furnishing the necessary construction equipment and tools, equipment operators, some skilled labor, most of the materials and the land. W.P.A. undertook to furnish unskilled labor and the supervision to direct it, as well as a limited amount of materials and equipment. The success or failure of a joint effort organized in this manner is vitally dependent upon wholehearted cooperation and confidence between the parties concerned in the undertaking. Fig. 1 shows the organization set-up of the project.

*Partner, Fay, Spofford & Thorndike, Consulting Engineers, 11 Beacon Street, Boston, Mass.
(Presented at a joint meeting of the Boston Society of Civil Engineers and Sanitary Section B.S.C.E., held on January 27, 1943.)



CRANSTON RHODE ISLAND SEWERAGE WORKS

ORGANIZATION DIAGRAM

FULL LINES SHOW ROUTES OF RESPONSIBILITIES
BROKEN LINES SHOW COOPERATIVE CONTACTS

FIG. 1.

The entire project includes nearly 96½ miles of gravity sewers, ranging in size from 8 inches to 42 inches; about 3½ miles of force main sewers, 8 inches to 24 inches in size; over 40 miles of sewer service connections, mostly 6-inch; seven sewage pumping stations, with designed capacities from 400 gallons per minute to 7,300 gallons per minute; and complete sewage treatment works, with normal capacity of 5.5 million gallons per day, providing primary treatment to remove grit, grease and settleable solids; secondary treatment by the activated sludge process; and units for disposal of sludge by digestion, vacuum filtration and incineration.

The construction of pumping station superstructures and the installation of pumping station equipment, as well as the entire construction of the sewage treatment works has been by contract; all other work was undertaken by the W.P.A. and City forces working together.

During the past three and one-half years, there have been built about 63 miles of gravity sewers and force main sewers, about 26¼ miles of service connections, five sewage pumping stations, and the sewage treatment works. In September of 1942, W.P.A. withdrew completely from participation in the project and the work now is being carried on by City forces alone. Construction progress originally was predicted by W.P.A. at the average rate of 850 feet per working day; the actual rate accomplished averaged 335 feet per working day up to the time when W.P.A. withdrew. Failure to accomplish the rates of progress anticipated naturally has been a substantial factor toward causing project costs to exceed materially those originally estimated.

Sewers and pumping stations were put into operation in February, 1942, and the sewage treatment works went into operation in March, 1942. Active service connections have been completed at the rate of about 46 per week and there are now nearly 2,100 active service connections, including those serving two large industrial plants. The average daily sewage flow is about 2.4 million gallons per day.

The sewage treatment works has operated effectively when handling normal domestic sewage, accomplishing a reduction of about 87 per cent in the biochemical oxygen demand and about 85 to 90 per cent reduction of suspended solids.

The treated sewage discharges into the Pawtuxet River about 4 miles above where the river enters Narragansett Bay.

THE SEWERS

There was no topographic map of the city, the only available information as to relative elevations being in the form of profiles showing established street grades. Consideration of the value of these data for making a layout of the entire sewer system led to a decision to lay out the arrangement of the sewers in the field rather than in the office, recording the layout and the necessary notes on a general street plan.

A W.P.A. project for basic plan data compiled the physical data as to existing underground structures and street surface profiles upon plans of the individual streets. These individual street plans were furnished the engineers for use in determining the exact limits of individual sewers, their locations in each street and the available laying slopes.

Design of Sewers

The sewers are designed as a system of separate sewers from which all storm water is excluded. The entire sewered area is to be served by three distinct sewer systems which finally merge at one main sewage pumping station.

The sewer designs are based on the following specific allowances:

(1) Sewer capacity is provided for the estimated maximum hourly rate of flow in 1970, with sewer flowing full; total estimated 1970 tributary population about 90,000 people.

(2) Present average population density about 10 persons per acre; present maximum population density about 30 persons per acre.

The 1970 average population density—about 17 persons per acre; 1970 maximum population density—about 60 persons per acre.

(3) The estimated 1970 average daily rate of water consumption, 100 gallons per capita; the 1970 maximum daily rate of water consumption, about 175 per cent of average daily rate; the 1970 maximum hourly rate of water consumption, about 140 per cent of maximum daily rate.

(4) Rates of sewage flow are based on estimates that only 70 per cent of water consumption reaches the sewers.

(5) Allowances are made for unforeseen concentrations of sewage flow for limited areas.

(6) Allowance for commercial sewage—maximum rate of 25,000 gallons per acre, per 24-hour day.

(7) Allowance for industrial sewage—maximum rate of 20,000 gallons per acre per 24-hour day.

(8) Allowance for infiltration of ground water into sewers, maximum rate of 25,000 gallons per mile of sewers per day.

In adopting sizes and slopes for the sewers, use has been made of hydraulic diagrams based on Kutter's formula. For vitrified pipe sewers, N in Kutter's formula was taken as .015 and for precast concrete pipe and asbestos-cement pipe, N was used as .013.

Infiltration Gagings. Gagings to measure the actual rate of infiltration have been made in two of the major systems of sewers. A gaging in Pocasset Valley sewer system with 35 miles of tributary sewers ranging from 8-inch to 42-inch showed an average rate of infiltration amounting to less than 7,500 gallons per mile of sewers per day. A gaging in Pawtuxet Avenue sewer system with 26 miles of tributary sewers ranging from 8-inch to 39-inch showed an average rate of infiltration less than 5,500 gallons per mile per day. These measured rates of infiltration may be expected to be somewhat greater during a season of extremely high ground water conditions but even then they would fall well within the limits of 25,000 gallons per mile per day allowed in the designs.

The sewer gagings also indicated a value N equals .013 in Kutter's formula for a stretch of 42-inch sewer built with precast centrifugal concrete pipe in 8-foot lengths, having the pipe joints smoothly pointed up with mortar on the inside of the pipe.

Minimum Velocities. The minimum velocities of flow adopted in designing sewers varied somewhat with the conditions of flow anticipated. The conditions of flow normally fall within one of three groups:

Group 1 includes sewers at the upper end of a sewer line which rarely will carry much, if any, infiltration and will operate under conditions of intermittent sewage flow, with the depth of flow ranging from no flow to perhaps one-half full. The intermittent flow in sewers under Group 1 must stir up and move material deposited from a preceding flush of sewage. For the conditions under Group 1, somewhat higher velocities are required than for the case of continuously flowing sewage. For Group 1 sewers, the minimum velocity adopted was 2½ feet per second, when flowing full.

Group 2 includes sewers in which there is normally sufficient infiltration or other steady flow so that the depth of flow ranges from, say, one-quarter full to one-half full or more. Sewers falling in Group 2 were designed for a velocity of at least 2 feet per second, or slightly more, when flowing full.

Group 3 includes sewers in which the depth of flow is practically always between half full and full, as in the case of main sewers or intercepting sewers. In these sewers there is the least tendency for deposits to be formed and the minimum velocity therefore was chosen only sufficient to ensure that sewage solids shall be carried along. For Group 3 sewers, the velocity, when flowing full, has been adopted of at least 1½ feet per second.

Sewer Design Calculations. Diagrams and tabular forms for calculations were used to simplify the sewer design work and to systematize the computations, and thereby facilitate checking. Fig. 2 shows a typical diagram used for calculating rates of domestic sewage flow and also shows the standard form used for recording sewer design calculations.

The rates of sewage flow for which the lower stretches of the three major sewer systems are designed are shown by Table I.

Sewer Materials. The materials used for the construction of sewers included vitrified clay or shale pipe, reinforced concrete pipe and asbestos-cement pipe. Decision to permit the use of asbestos-cement pipe was not made until information had been obtained as to its previous use for sewers, and until a rating of its merits showed it to compare very favorably with the other kinds of pipe. Table II shows a theoretical rating study of the various kinds of sewer pipe, from which it will be noted that the summary of ratings indicates asbestos-cement pipe to have the best rating, reinforced concrete pipe to have the second best rating and vitrified clay pipe to be rated third.

Sewer pipe joints were specified to consist of caulked jute, slightly oiled for ease in caulking, and bituminous sewer jointing compound melted and poured in place. No jute is used for joints in asbestos-cement pipe. Fig. 3 shows the make-up of pipe joints for the three different kinds of pipe used.

Cradling of Pipe. In all instances, the sewer pipe was required to have a liberal bedding of gravel and generous use was made of cradling wherever trench loads or live loads indicated its use. Fig. 5 shows typical methods of pipe bedding and pipe cradling which were used. A thorough bedding of the sewer pipe in granular material is

ALLOWANCES

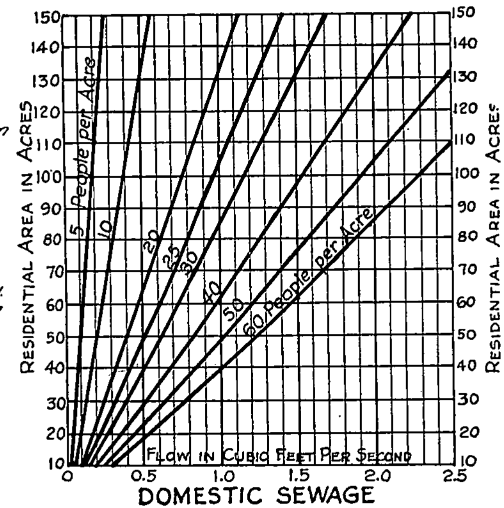
Water Consumption: Average daily rate 100 gallons per capita per day. Maximum hourly rate 250% of average daily.

Domestic Sewage: 70% of water consumption reaches sewers. Maximum sewage rate including allowance for concentrated flow from small areas 285 gallons per capita per day for 5 acres and decreasing to 245 gallons per capita for areas of 100 acres or more.

Infiltration: 25,000 gallons per day per mile of sewer or 600 gallons (.001 cu. ft. per sec.) per acre per day (Maximum Rate)

Commercial Sewage: 25,000 gallons (.039 cu. ft. per sec.) per acre per day. (Maximum Rate)

Industrial Sewage: 20,000 gallons (.031 cu. ft. per sec.) per acre per day. (Maximum Rate)



Computations for Separate Sewers

Section	Portion of Sewer			Adjacent Area						Total Tributary Area					Maximum Volume of Sewage					Proposed Sewer Data										
	Location or Street	Stations or Limits		Total Acres	Industrial Acres	Commercial Acres	Domestic Acres	Population		Industrial Acres	Commercial Acres	Domestic Acres	Population		Cubic Feet per Second					Pipe						Invert Elevation		Cut		
		From	To					Per A	Total				Per A	Total	Industrial	Commercial	Domestic	Infiltration	Total	Size	Slope	Velocity F/s Full	Velocity F/s Actual	Depth of Flow	Length	Upper End	Lower End	Upper End	Lower End	Average
a	Westview Av.	Northview Av.	Palmer St.	49	5	4	40	27	1080	5	4	40	27.0	1080	.155	.156	.440	.049	.800	8"	.008	2.35	2.72	6.16	850	120.00	113.20	7.5	11.5	9.5
b	Park Av.	Palmer St.	River St.	37	3	7	27	19	513	8	11	67	23.8	1593	.248	.429	.650	.086	1.413	10"	.007	2.65	3.02	7.8	1260	113.03	104.21	11.5	8.5	10.0
c	Church St.	South St.	Cranston St.	29	8	1	20	25	500	16	12	87	24.1	2093	.496	.468	.852	.115	1.931	12"	.0045	2.41	2.70	9.7"	1880	104.04	95.58	8.5	12.0	10.25
d	George St.	Chestnut St.	Colonial St.	63	-	10	53	21	1113	16	22	140	22.9	3206	.496	.858	1.300	.178	2.832	15"	.003	2.35	2.72	11.95	1760	95.33	90.05	12.0	11.0	11.50

FIG. 2.—TYPICAL DIAGRAM AND FORM FOR CALCULATING SEWER DESIGNS.

TABLE I

Cranston, Rhode Island

Summary of Sewage Rates Estimated for Maximum Hour in 1970

Name of Sewer System	Tributary Population 1970	Domestic Area (Acres)	Domestic Rate Cu. Ft. per sec.	Commercial Area (Acres)	Commercial Rate Cu. Ft. per sec.	Industrial Area (Acres)	Industrial Rate Cu. Ft. per sec.	Infiltration Area (Acres)	Infiltration Rate Cu. Ft. per sec.	Total Area (Acres)	Total Rates Cu. Ft. per sec.	Total Rates Million gals. per day	Gallons per Capita per Day for 1970 Population
Pocasset Valley	56,290	3,059	21.33	270	10.53	349	10.82	3,678	3.68	3,678	46.36	30.0	535
Wellington Ave.	14,060	773	5.32	107	4.18	181	5.38	1,061	1.06	1,061	15.94	10.3	730
Pawtuxet Ave.	19,800	1,028	7.51	68	2.65	113	3.73	1,209	1.21	1,209	15.10	9.8	495
	90.150									5,948			

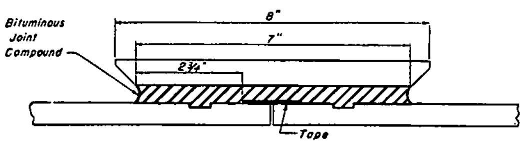
TABLE II

CRANSTON, RHODE ISLAND

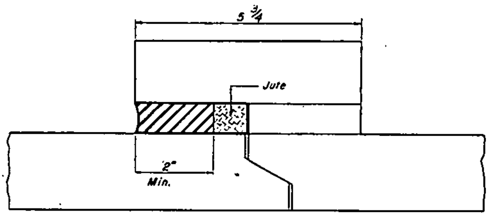
THEORETICAL RATING* STUDY OF VARIOUS KINDS OF SEWER PIPE

	Strength	Ability to Withstand Leakage	Ability to Withstand Action of Sewage	Ease of Handling and Assembling	Experience Background	Summary of Ratings
Asbestos-Cement Pipe	2	1	2	1	3	9
Reinforced Concrete Pipe	1	2	3	2	2	10
Vitrified Clay Pipe	3	3	1	3	1	11

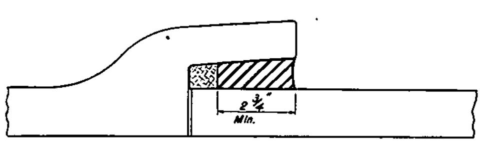
*In the ratings given, 1 is the highest rating.



ASBESTOS — CEMENT PIPE JOINT



REINFORCED CONCRETE PIPE JOINT



VITRIFIED PIPE JOINT

FIG. 3.—TYPICAL JOINTS FOR SEWER PIPE.

estimated to improve its resistance to failure by from one and one-half to two times the load which the pipe can carry in three-edge bearing

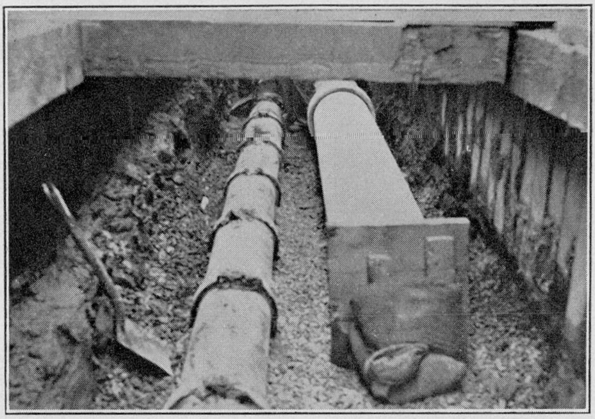


FIG. 4.—VITRIFIED CLAY PIPE GRAVITY SEWER AND ASBESTOS-CEMENT PIPE FORCE MAIN SEWER IN SAME TRENCH.

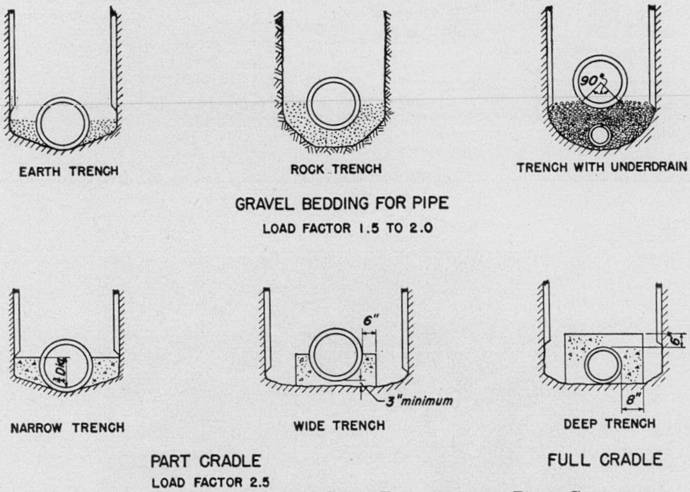


FIG. 5.—TYPICAL METHODS OF PIPE BEDDING AND PIPE CRADLING.

tests, and pipe embedded in part concrete cradle is estimated to support about two and one-half times the ultimate load indicated by three-edge bearing test.* Pipe completely incased in concrete is suitable to carry even greater loads.

Manholes. Manhole structures were designed with a combination of brickwork and concrete. Sectional metal forms were used for the

*For a discussion of Earth Loads on Sewer Pipe in Trenches, refer to paper by W. L. Hyland published in Journal of Boston Society of Civil Engineers, January 1941.

concrete walls of manholes. Adoption of concrete manholes was intended to reduce to a minimum the need of brick masons and to improve watertightness. The use of brickwork for certain parts of the manhole structures was intended to simplify manhole construction work required of the W.P.A. crews. Fig. 6 shows the details of construction for a

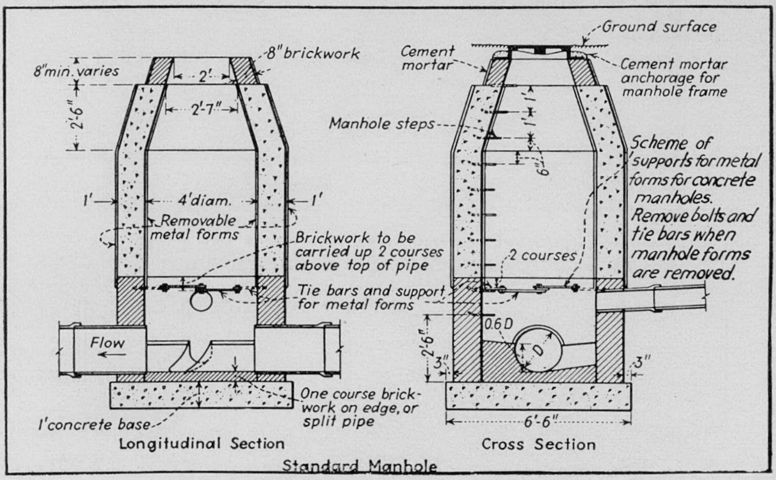


FIG. 6.

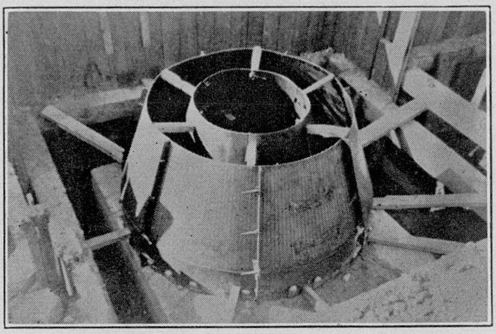


FIG. 7.—SECTIONAL STEEL FORMS IN PLACE FOR POURING CONCRETE MANHOLE.

typical manhole built with a combination of brickwork and concrete. Where reinforced concrete pipe sewers and asbestos-cement pipe sewers were used, short lengths of pipe were laid rather than standard lengths to connect with manholes as a precaution against pipe rupture due to excessive bending stresses. Standard manhole construction called for circular manholes but in the case of shallow manholes, square or rectangular manhole structures were adopted in order to provide maximum space inside them.

CONSTRUCTION OF SEWERS

The first step in the construction program was the erection of a suitable warehouse with ample yard space for outside storage. The warehouse was centrally located within the area of construction operations and was adjacent to a siding along the main line of the New York, New Haven and Hartford Railroad.

FIG. 8.—WAREHOUSE AND YARD FOR STORING MATERIALS TO BE USED ON THE PROJECT.

Practically all materials, tools and equipment for sewer construction were purchased on a competitive basis under definite specification requirements. Separate construction specifications were provided for directing the W.P.A. in carrying out the construction operations.

Construction Organization. The normal procedure in the construction of sewers involved four separate steps in sequence:

(1) Laying of sewer pipe lines
(2) Construction of manholes
(3) Construction of service connections, and
(4) Street repair and cleanup work

The entire W.P.A. working force was divided into construction units. At times, there were as many as 2,000 W.P.A. workers distributed over four working shifts of six hours each; the number of construction units ranged from eight, at the peak of construction activities, to three during the last two or three months of W.P.A. participation in the project.

The typical set-up for a sewer construction unit included the items on the following page.

Progress. The sewer construction work for the most part was ordinary straightforward work involving a large percentage of sandy material and ground water and some deep excavations. But very little rock excavation was involved. Most of the work was in highways and numerous underground utilities were encountered. The use of well point systems was a very important factor in expediting the construction.

During the time that W.P.A. participated in building the project there was laid a total of nearly 320,000 feet of sewer lines and 130,000 feet of service connections, and 1,575 manholes were built. The average rate of sewer construction per working day was 335 feet and ranged from a maximum of nearly 1,340 feet per working day during the best week's progress to a minimum of 22 feet per working day during the week of least progress. Progress rates per construction unit ranged from a maximum of 222 feet per working day during the best week to a minimum of 4 feet per day and for the entire time that W.P.A. worked, the average rate per working day per unit was about 55 feet. Record of the progress accomplished is shown graphically by Fig. 9.

Upon the withdrawal of W.P.A. from the project in September 1942, the construction of sewers was continued, using labor hired on the City pay roll, employing in part the same labor and foremen furnished by W.P.A.

Costs. The City has endeavored to keep reliable cost records for the project and an audit of the costs has been made at least once a year and in some years more frequently. The cost records also cover the best information which the City could obtain regarding W.P.A. costs. Unit construction cost figures derived from the latest audit, which covers about 39 months' operation, are given in Tables III and IV.

TYPICAL "SET-UP" FOR A SEWER CONSTRUCTION UNIT

Equipment	Labor — Furnished by W.P.A.	Labor — Furnished by City
1 Backhoe, ¾ cu. yd., or 1 Trenching Machine	1 General Foreman,—for 2 shifts	2 Digging Machine Operators
1 Crane equipped with ½ or ¾ cu. yd. Clamshell Bucket	1 Grade "A" Foreman	2 Pump Men
1 Portable, 210 cu. ft. per minute capacity, Air Compressor	1 Grade "B" Foreman	1 Compressor Operator
1 Portable, 105 cu. ft. per minute capacity, Air Compressor,—serving 2 units on service connections	2 Carpenters	1 Tractor Operator,—½ time
1 Tractor equipped with sheeting pulling attachment and scraper blade, for backfilling,—serving two units	1 Production Clerk,—for 2 shifts	3 Truck Drivers
2 Centrifugal Pumps—2" and 4" size	3 Pipe Layers	1 Brick Mason
1 One-bag Concrete Mixer,—serving two units	2 Jack Hammer Operators	
2 Twenty-five gallon Heaters, for melting sewer joint compound	6 Shorers	
3 Pneumatic Sheet Pile Hammers	1 Mixer Operator—½ time	
2 Paving Breakers	14 Trench and Tunnel Men	
3 Trucks, 2 @ 1½ tons and 1 @ 5 tons	1 Timekeeper	
Miscellaneous small tools, including shovels, tampers, picks, wheelbarrows, jointing tools, lanterns, etc.	16 Laborers	
	2 Watchmen	

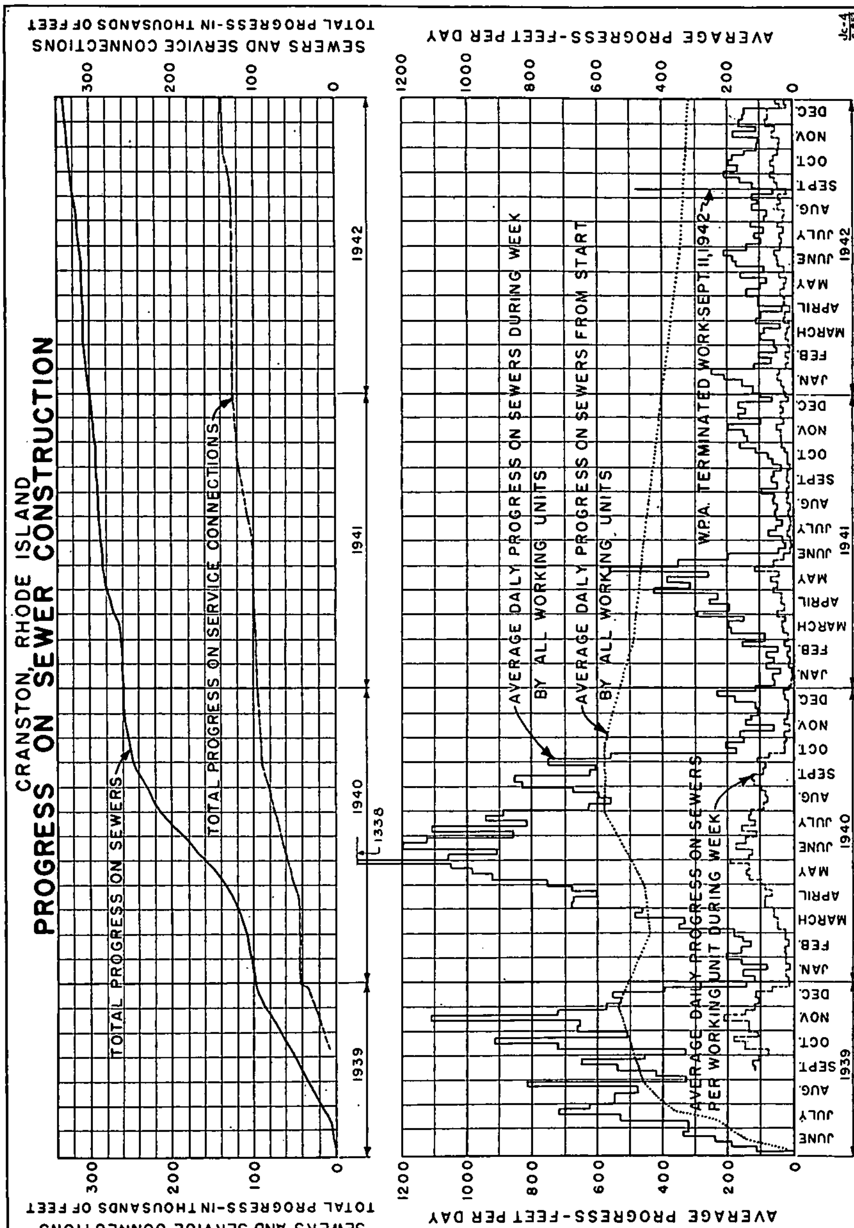

CRANSTON, RHODE ISLAND
PROGRESS ON SEWER CONSTRUCTION
SEWERS AND SERVICE CONNECTIONS
TOTAL PROGRESS-IN THOUSANDS OF FEET
TOTAL PROGRESS ON SEWERS
TOTAL PROGRESS ON SERVICE CONNECTIONS
AVERAGE PROGRESS-FEET PER DAY
AVERAGE DAILY PROGRESS ON SEWERS DURING WEEK BY ALL WORKING UNITS
AVERAGE DAILY PROGRESS ON SEWERS FROM START BY ALL WORKING UNITS
AVERAGE DAILY PROGRESS ON SEWERS PER WORKING UNIT DURING WEEK
W.P.A. TERMINATED WORK-SEPT. 11, 1942
1338
1939
1940
1941
1942

FIG. 9.

TABLE III

Cranston, Rhode Island, Sewerage Works

Indicated Unit Costs for Sewer Construction
Based on Cost Audit for Period June 5, 1939 - September 30, 1942

The costs given are per linear foot of common sewer complete, and include the cost of manholes, resurfacing and service connections built from the common sewer to the property lines.

DESCRIPTIONS OF SEWERS ON WHICH COSTS ARE BASED								
	Case P.V.1	Case P.V.1(a)	Case P.V. 2	Case P.V. 3	Case P.V.3(a)*	Case P.V. 4	Case P.V. 5	Case P.V.5(a)*
Length of common sewer	36,419 ft.	4,426 ft.	5,949 ft.	27,575 ft.	2,970 ft.	29,345 ft.	60,147 ft.	1,487 ft.
Sizes of Sewer	88%=8"; 10%=10" 2%=12"	2%=10"; 14%=12" 72%=14"; 12%=15"	67%=8"; 33%=10"	58%=8"; 28%=10" 1%=12"; 8%= 14" 5%=20"	100% = 10" *	52%=8"; 30%=10" 10%=18"; 8%=24"	59%=8"; 21%=10" 4%=12"; 5%=15" 10%=18" Bal.14" 16" 20" 21" 24"	100% = 16" *
Average Depth of Trench	8.63 ft.	8.01 ft.	8.13 ft.	8.30 ft.	7.86 ft.	9.28 ft.	8.62 ft.	9.00 ft.
Kind of Digging	Medium sand-dry	Fine sand-wet	Medium fine sand - dry	50% Medium sand 1/3 wet, 2/3 dry 50% sandy clay-dry	Medium sand - 1/2 wet and 1/2 dry	50% Fine sand-dry 50% Coarse sand & gravel-dry	40% Medium sand-dry; 40% Coarse sand & gravel-dry; 20% clay & ledge - wet	50% Fine sand-dry 50% Coarse sand & gravel-dry; incl. R.R. Crossing
Trench length with sheeting left in place	2.44%	47.33%	None	0.36%	None	1.27%	2.20%	1.34%
Length of Sewer Service Connections	26,843 ft.	None	3,296 ft.	10,961 ft.	None	12,252 ft.	24,783 ft.	None
UNIT COST TO CITY								
Mat'ls & Supplies, Eqpt. & Tools	$2.69	$5.58	$2.58	$2.55	$2.99	$2.87	$2.88	$7.61
Labor	0.72	0.65	0.68	0.82	1.31	0.93	1.37	2.66
Engineering	0.92	0.90	0.92	1.00	0.73	1.13	1.23	1.75
Legal & Administrative	0.14	0.56	0.14	0.13	0.14	0.13	0.15	0.26
Total Unit Cost to City	$4.47	$7.69	$4.32	$4.50	$5.17	$5.06	$5.63	$12.28
UNIT COST TO W.P.A.								
Mat'l & Equipment	$0.10	$0.02	$0.10	$0.29	$0.16	$0.43	$0.97	$ 0.80
Labor	5.37	5.31	3.28	5.04	5.08	6.03	7.87	8.43
Administrative	0.10	0.10	0.06	0.10	0.10	0.12	0.17	0.18
Total Unit Cost to W.P.A.	$5.57	$5.43	$3.44	$5.43	$5.34	$6.58	$9.01	$9.41
GRAND TOTAL UNIT COST	$10.04	$13.12	$7.76	$9.93	$10.51	$11.64	$14.64	$21.69

*This is a force main sewer built with asbestos-cement pressure pipe.

TABLE IV

Cranston, Rhode Island, Sewerage Works

Indicated Unit Costs for Sewer Constructions
Based on Cost Audit for Period June 5, 1939 - September 30, 1942

The costs given are per linear foot of common sewer complete, and include the cost of manholes, resurfacing and service connections built from the common sewer to the property lines.

DESCRIPTIONS OF SEWERS ON WHICH COSTS ARE BASED								
	Case P.V. 6	Case W.A. 1	Case W.A. 2	Case W.A. 3	Case W.A. 4	Case P.A. 1	Case M. O.	Case F.M.O.*
Length of common sewer	16,411 ft.	46,166 ft.	46,893 ft.	16,258 ft.	16,514 ft.	7,053 ft.	770 ft.	2,949 ft.
Sizes of sewer	8%=10"; 5%=21" 10%=24"; 6%=27" 37%=39"; 32%=42" Bal. 14" 15"	67%=8"; 15%= 10" 7%=12"; 3% = 14" 2%=20"; 5% = 24" Bal. 18"	58%=8"; 22%=10" 6%=12"; 9%=18" 4%=24" Bal. 14" 15" 20"	69% = 8" 31% = 10"	66%=8"; 11%=10" 8%=12"; 3%=27" 12%=30"	4%=12"; 40%=30" 56% = 39"	1% = 24" 28%= 30" 71%= 36"	100% = 24" *
Average Depth of Trench	9.91 ft.	9.46 ft.	9.43 ft.	8.29 ft.	11.43 ft.	8.15 ft.	6.63 ft.	5.46 ft.
Kind of Digging	Fine sand - wet	60% Fine sand - dry (some clay) 40% Fine sand - wet (some clay)	40% Medium to fine sand-dry (some clay) 60% Medium to fine sand-wet (some clay)	Medium to fine sand-dry	60% Fine to coarse sand & gravel-wet 40% Fine sand-dry (includes 1400' of 30" at 20' to 30' cut)	Fine sand some clay - wet	Medium sand-dry	Medium sand-dry
Trench length with sheeting left in place	42.44%	1.92%	4.03%	7.84%	6.50%	None	2.60%	8.07%
Length of Sewer Service Connections	349 ft.	26,621 ft.	14,207 ft.	8,335 ft.	6,959 ft.	28 ft.	None	None
UNIT COST TO CITY								
Mat'ls & Supplies, Eqpt. & Tools	$10.34	$3.49	$4.19	$2.67	$6.08	$10.47	$6.52	$7.04
Labor	5.39	1.61	2.53	1.01	2.64	5.59	3.17	4.59
Engineering	3.31	0.90	1.00	0.82	1.49	3.10	2.16	3.11
Legal & Administrative	0.57	0.12	0.26	0.10	0.19	1.03	0.96	0.86
Total Unit Cost to City	$19.61	$6.12	$7.98	$4.60	$10.40	$20.19	$12.81	$15.60
UNIT COST TO W.P.A.								
Mat'ls & Equipment	$3.72	$0.90	$0.78	$0.70	$0.93	$0.76	$1.54	$1.18
Labor	21.15	6.89	6.75	4.56	8.82	11.37	9.03	5.35
Administrative	0.50	0.12	0.09	0.10	0.05	0.18	0.25	0.21
Total Unit Cost to W.P.A.	$25.37	$7.91	$7.62	$5.36	$9.80	$12.31	$10.82	$6.74
GRAND TOTAL UNIT COST	$44.98	$14.03	$15.60	$9.96	$20.20	$32.50	$23.63	$22.34

*This is a force main sewer built with asbestos-cement pressure pipe.

Operation and Maintenance of Sewers

The force which has been set up for handling sewer maintenance work includes six men; namely, an engineer-in-charge, truck driver, foreman, pipe-layer, and two sheathers. The duties of the sewer maintenance force include periodic sewer inspection, cleaning and flushing, repair of sewer pipes as necessary, and the construction of isolated sewer service connections in areas where the sewer system has been put into operation.

The annual pay roll for the sewer maintenance force, based on an average 9-hour working day, six days per week, is about $12,000.

THE SEWAGE PUMPING STATIONS

The sewer system includes seven sewage pumping stations, of which five already have been constructed.

Design of Pumping Stations

Each pumping station was designed with total pumping capacity, including the stand-by pump units, sufficient for handling the maximum estimated hourly rates of sewage flow 15 years in the future.

Force main sewers, which carry the discharge from the pumping stations, are designed to carry the maximum pumping rate without excessive loss of head, and to give a velocity of flow of about two feet or more per second, when carrying the discharge of one single pump unit. Force main sizes have been designed, using a value of "C" equals 100, in Hazen and Williams' formula. Bids for force main pipe of either cast iron, asbestos-cement or reinforced concrete have been invited, but no bids for cast iron pipe have been received and either asbestos-cement pipe or reinforced concrete pipe has been used. Joints in asbestos-cement pipe are made with Simplex couplings and rubber rings; joints in reinforced concrete pipe are specified to be poured with either "Leadite" or "Hydrotite."

Table V shows a summary of the design features of the several sewage pumping stations and their respective sewer force mains.

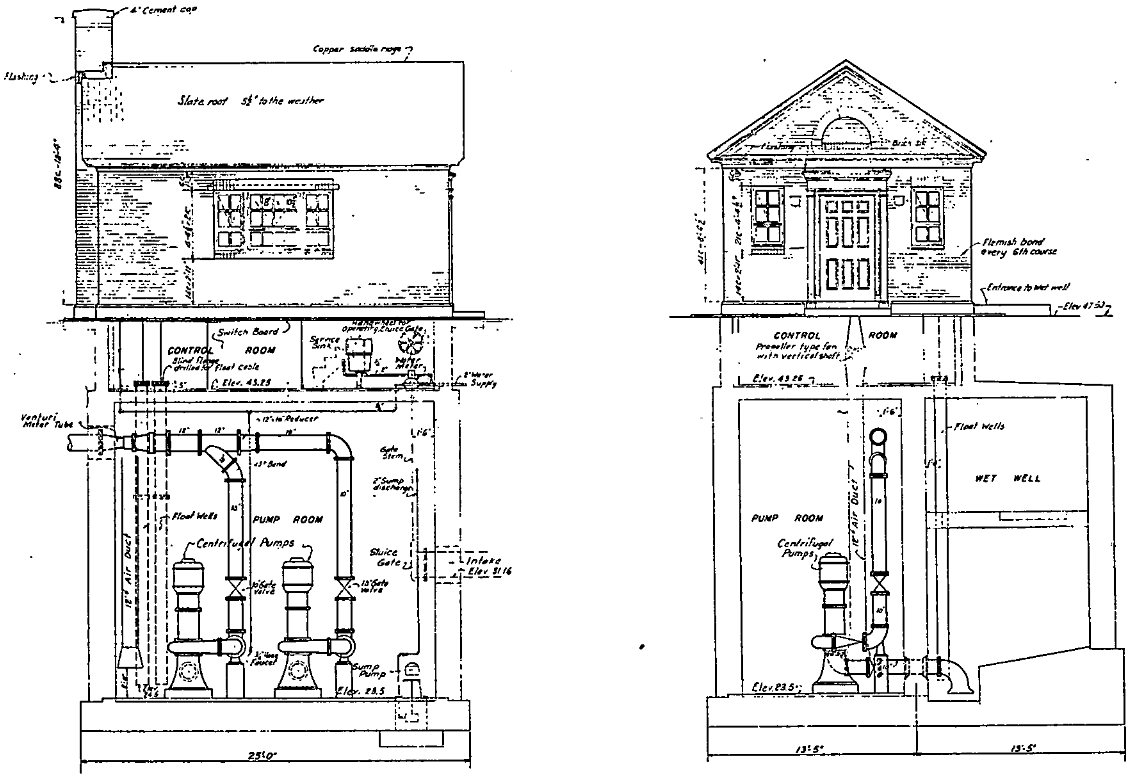
Arrangement of Stations. Each pumping station consists of a reinforced-concrete substructure with either brick or reinforced-concrete superstructure. The substructure of each pumping station is divided by a vertical wall into two parts. One part is a wet well in which the sewage accumulates from the tributary gravity sewers before

TABLE V

Cranston, Rhode Island
Design Features of Sewage Pumping Stations and Force Mains

Name of Pumping Station	Tributary Area (Acres)	Tributary Population Est. for Year 1955	Maximum Hourly Rate of Sewage Flow (G.P.M.—1955)	Number of Pumps	Normal Capacity of Each Pump Unit (G.P.M.)	Normal Total Pumping Head One Pump Operating	Size of Solids That Pump Will Pass (Inches)	Force Main Size Diam. in Inches	Force Main Velocity One Pump Operating (Ft. per Sec.)
Bay Street	63	1,800	400	2	300(b)	45 ft.	2½	8	1.9
Burnham Ave.	500	5,800	2,900	2	2,000(b)	53 ft.	4×2½	16	3.2
Dyer Ave.	100	1,700	760	2	600(b)	47 ft.	2½	10	2.5
Mayflower Drive	1,000	14,400	4,100	2	3,000(b)	35 ft.	5	24	2.1
					2 @ 3,000(a)	40 ft.	6×3		2.1
Pontiac Ave.	5,948	50,000	7,300	4	2 @ 3,500(b)	41 ft.	6×3	24	2.5
Sheldon St.	114	2,600	530	2	400(b)	49 ft.	2½	8	2.6
Wellington Ave.	446	5,400	2,700	2	2,000(b)	39 ft.	4×2½	16	3.2

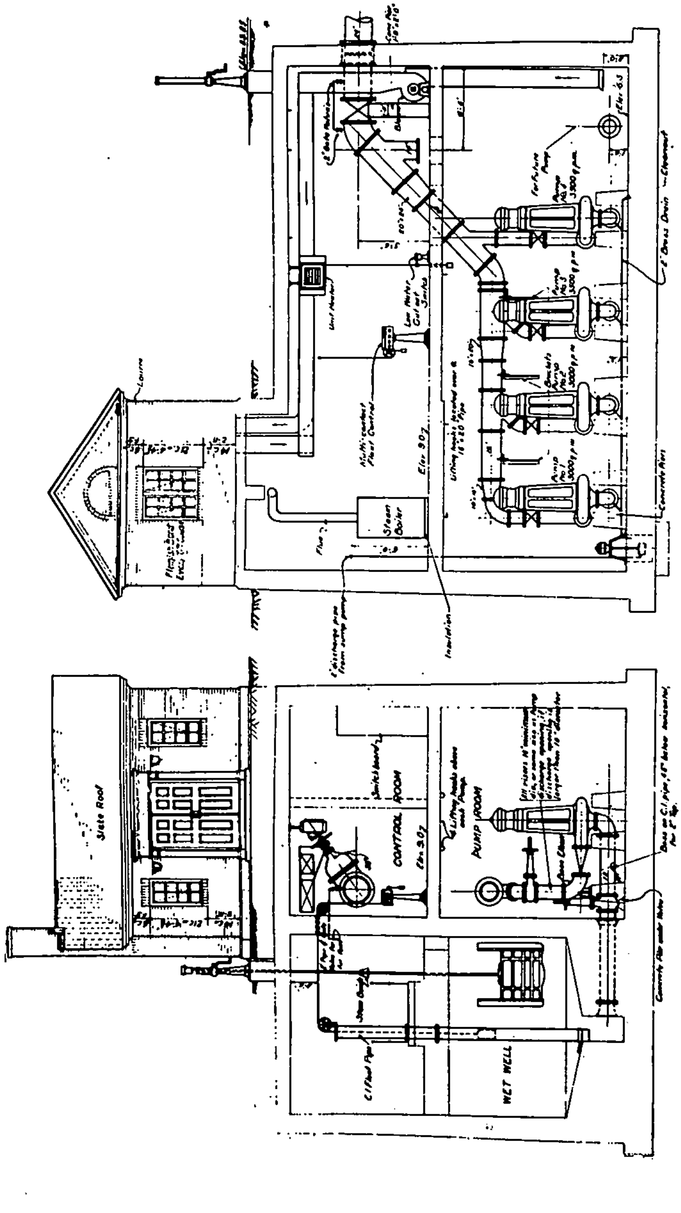
(a) Variable Speed Units.
(b) Constant Speed Units.



TYPICAL ARRANGEMENT OF SEWAGE PUMPING STATIONS

0 2 4 6 8
Scale in Feet

FIG. 10.



ARRANGEMENT OF MAIN SEWAGE PUMPING STATION

Fig. 11.

being pumped; the other part consists of two rooms, one above the other, the lower room being designated the pump room and the upper room, the control room. A spiral stairway extends from the control room to the pump room. Fig. 10 and Fig. 11 indicate the physical arrangement of the pumping stations. The pump units are set in the pump room and the control room houses the switchboard, meter instruments and heating and ventilating facilities. In most cases, the floor of the control room is about 4 feet below the finished ground level outside and the upper portion of the control room is housed by the superstructure. The only entrance to the wet well is from the outside.

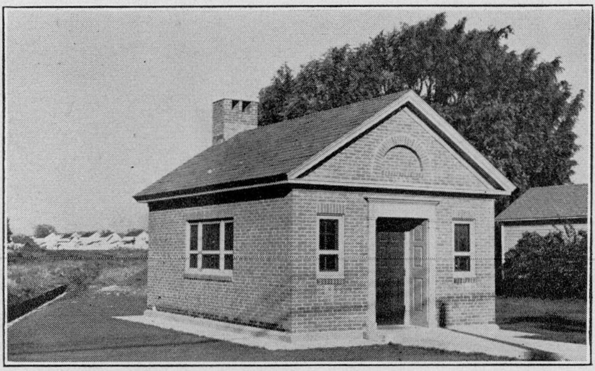


FIG. 12.—TYPICAL SUPERSTRUCTURE OF SEWAGE PUMPING STATIONS.

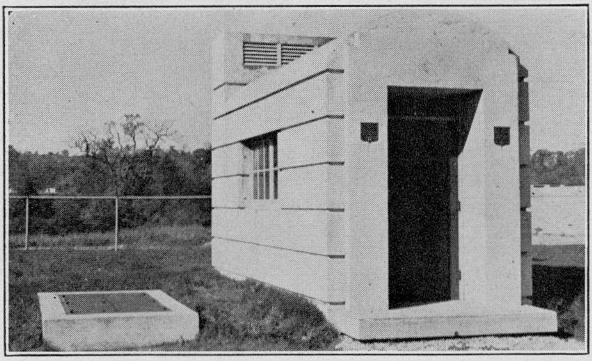


FIG. 13.—SPECIAL SUPERSTRUCTURE FOR A SEWAGE PUMPING STATION.

In the case of the main pumping station, which is designated Pontiac Avenue pumping station, the control room is entirely below ground level and the superstructure is a small brick building, the principal function of which is to provide access to the substructure through which to bring in and remove the equipment; the superstructure also provides limited office space for the pumping station operator to prepare and keep his records.

Pump Units. Each pump unit consists of a vertical, centrifugal pump with non-clog impeller, close coupled by flexible coupling to an electric motor. Motors are supported by ring castings mounted on the

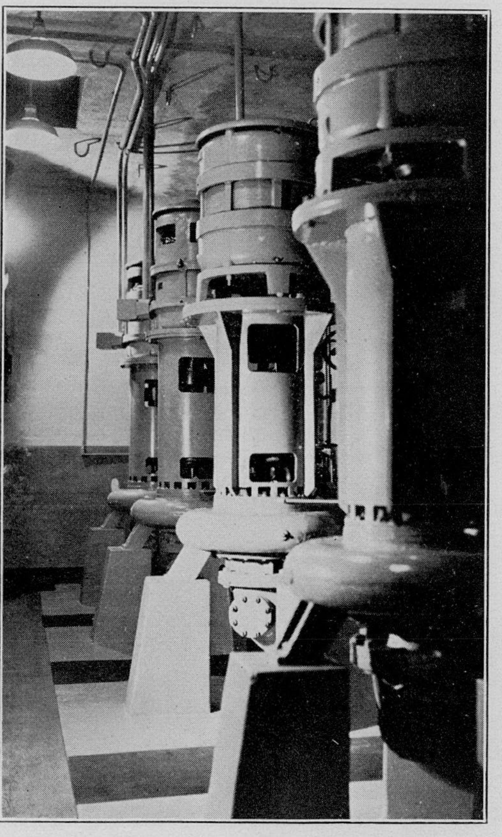


FIG. 14.—SEWAGE PUMP UNITS AT MAIN SEWAGE PUMPING STATION.

pump casings. No provisions have been made for screening of the sewage since the pumps are large enough to permit the passage of sizable solids through them. Pump impellers are enclosed, two-vane type, each impeller being cast in a single piece. Pump shafts are protected from contact with sewage liquids by renewable sleeves. Pumps are dry pit style. The pumps having a capacity of 2,000 gallons per minute or less are supported by pedestal castings resting on a shallow concrete base and the pumps of more than 2,000 gallons per minute capacity are supported by cast feet projecting from the pump casings and resting on individual concrete piers. The operation of each pump is automatically controlled by a float actuated by the sewage level in the wet well of the pumping station. Pumping operations at each pumping station will be intermittent except in the case of Pontiac Avenue pumping station, which discharges directly to the sewage treatment works. It is the intention that this pumping station shall operate continuously, to deliver a steady flow of sewage to the treatment works with gradual changes in the rate of delivery. Constant speed pumps are used in all stations except Pontiac Avenue pumping station, which has two constant speed pumps and two variable speed pumps, the two variable speed pumps being intended to facilitate continuous pumping at this station.

Motors for constant speed pumps are of the squirrel cage, induction motor type and the variable speed motors are wound-rotor, slip-ring, induction motors.

Control of Pump Operations. The controls for starting and stopping pump units are so set that pumping from the sewage wet wells will commence when sewage accumulates in the wells to the crown of the lowest entering sewer and pumping is planned to stop when the sewage level has been drawn down within two to three feet above the mouth of the pump suction pipe. In the case of Pontiac Avenue pumping station, which is equipped with two variable speed 3,000 g.p.m. pump units and two constant speed 3,500 g.p.m. pump units, the control of pumping operations is by means of a multiple circuit program control actuated by a single float in the wet well. The program control switch provides 14 separate steps or combinations of pumping rates, of which four are for use with a future pump unit. The multiple circuit program control when operating with the four initial pump units, provides an estimated range of pumping rates from 1,000 gallons per minute to about 8,800 gallons per minute, the latter value being less than the total of the four individual pump capacities due to the effect of balancing the force main system-head-curve and the performance characteristics of the pumps.

Venturi meters are provided to indicate and record the rate of discharge of each pumping station.

Heating and Ventilation. Heating and ventilation was generally accomplished by installation of an oil burning, direct radiation heater in the control room and an ordinary kitchen type ventilating fan en-

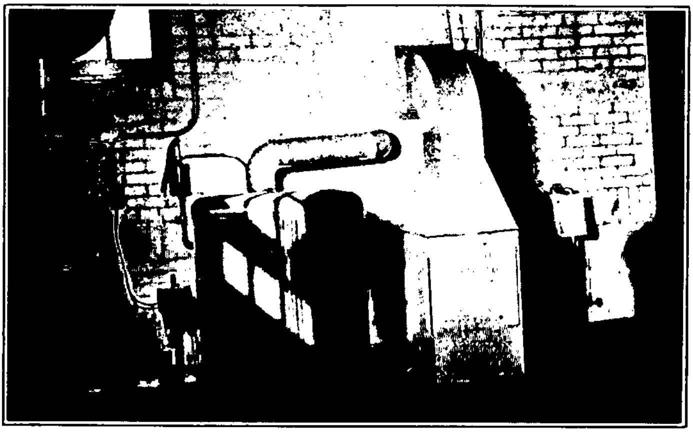


FIG. 15—TYPICAL HEATING AND VENTILATING UNITS. (1) OIL BURNING DIRECT RADIATION HEATER. (2) VENTILATING FAN ENCLOSED IN AIR DUCT PIPING.

closed in suitable air duct piping, the fan and piping being arranged to draw cold and damp air from a level about two feet from the pump room floor and discharge it into the chimney of the building or by use of a damper to recirculate the air by discharging it into the control room. Warm air from the heating unit circulates down the spiral stairway to replace the air drawn from the lower portion of the pump room. Heating for Pontiac Avenue pumping station is provided in part by an oil burning steam boiler in the control room which supplies radiators in the superstructure, and also by means of a unit heater in the control room. A blower and duct system provides for ventilation of the control room and the pump room whereby air may be taken from a level near the floor of the pump room and discharged into the control room or to the outside. Fresh air also may be taken from the outside and brought into the control room.

Contract for Pumping Station Equipment. All pumping equipment and electrical controls, together with meters, piping, wiring, appurtenances for the mechanical and electrical installation and the actual installation work, was handled under one contract. To assist the bidders in offering proper pumps, the specifications provided a set of system-head-curves indicating the expected total pumping heads for various rates of discharge at each of the several pumping stations. Each bidder was required to furnish characteristic pump curves for each pump bid.

The award of contract for all pump units for the seven pumping stations was made to one contractor on the basis of the combined amount bid for furnishing and installing equipment and materials plus the contractor's calculated cost of power for pumping during an initial five-year period based on his quoted pump and motor efficiencies and a rate for electric current stated in the specifications.

Construction of Pumping Stations

Each pumping station has been built in three separate steps, namely—

(1) Construction of substructure by W.P.A. and City forces

(2) Construction of superstructure by contract

(3) Furnishing and installation of pumping equipment, electrical controls and all their appurtenances by contract.

Substructures. Each substructure was built in a cofferdam of steel sheet piling braced with heavy wooden timbers. The same sheet piling has been used over and over again for the cofferdams at the pumping stations and is now reconditioned and ready for use.

The typical set-up of a construction unit for building substructures is shown on the following page.

Sewage pumping stations, by the nature of their purpose, are built at the low part of the territory they serve. All of the pumping stations involved the handling of ground water in their construction and the excavation was uniformly of very fine sandy material carrying some silt. Depth of excavation for the structures ranged from about 20 to 25 feet. Dewatering for the first two stations was satisfactorily handled without well points by pumping from two pump sumps provided at

TYPICAL "SET-UP" FOR BUILDING PUMPING STATION SUBSTRUCTURES

Equipment	Labor: Furnished by W.P.A.	Labor: Furnished by City
1—Crane equipped with ½ or ¾ cu. yd. Clamshell Bucket	1—Superintendent	1—Crane Operator
1—Truck	1—Asst. Superintendent	1—Truck Driver
2—Portable, 210 cu. ft. per minute capacity, Air Compressors	1—General Foreman	2—Pump Men
1—Air Hammer to drive steel sheet piling	1—Iron Worker	1—Carpenter
1—Well point system with Pump	3—Carpenters	
2—Suction Ditch Pumps	1—Cement Finisher	
1—Concrete Mixer	1—Production Clerk	
	1—Timekeeper	
	2—Trench and Tunnel Men	
	5—Laborers	
	2—Watchmen	

diagonally opposite corners within the cofferdams. Well points were very necessary for building the other three pumping stations and in two instances, a system of well points was installed outside the cofferdam, as well as inside, in order to handle the ground water in a satisfactory manner. The handling of ground water in the case of Mayflower Drive pumping station was quite difficult; the underlying material was very fine and considerable of it was removed through the well-point system. Difficulty in holding a satisfactory bottom, even with the generous use of gravel ballast, made it necessary to drive 30-foot piles for supporting this station.

In constructing cofferdams for all stations, liberal allowance of space was made between the outside limits of the substructures and the cofferdams. This space was usually about 3½ to 4 feet wide. The largest cofferdam was about 45 feet by 50 feet inside and the smallest cofferdam about 26 feet by 32 feet inside.

Superstructures. Pumping station superstructures in all cases were relatively small buildings, usually constructed with brick walls and slate roofs on wood framing. Red sandstruck brick were used for exterior walls and sand-lime brick for interior walls. The contracts for superstructures included, besides the buildings, the heating and ventilating facilities and all iron work such as spiral stairways, steel frames and covers for openings through concrete slabs, pipe railings and the like.

Progress and Costs. The working time for constructing substructures of the several pumping stations, including excavation, coffer-

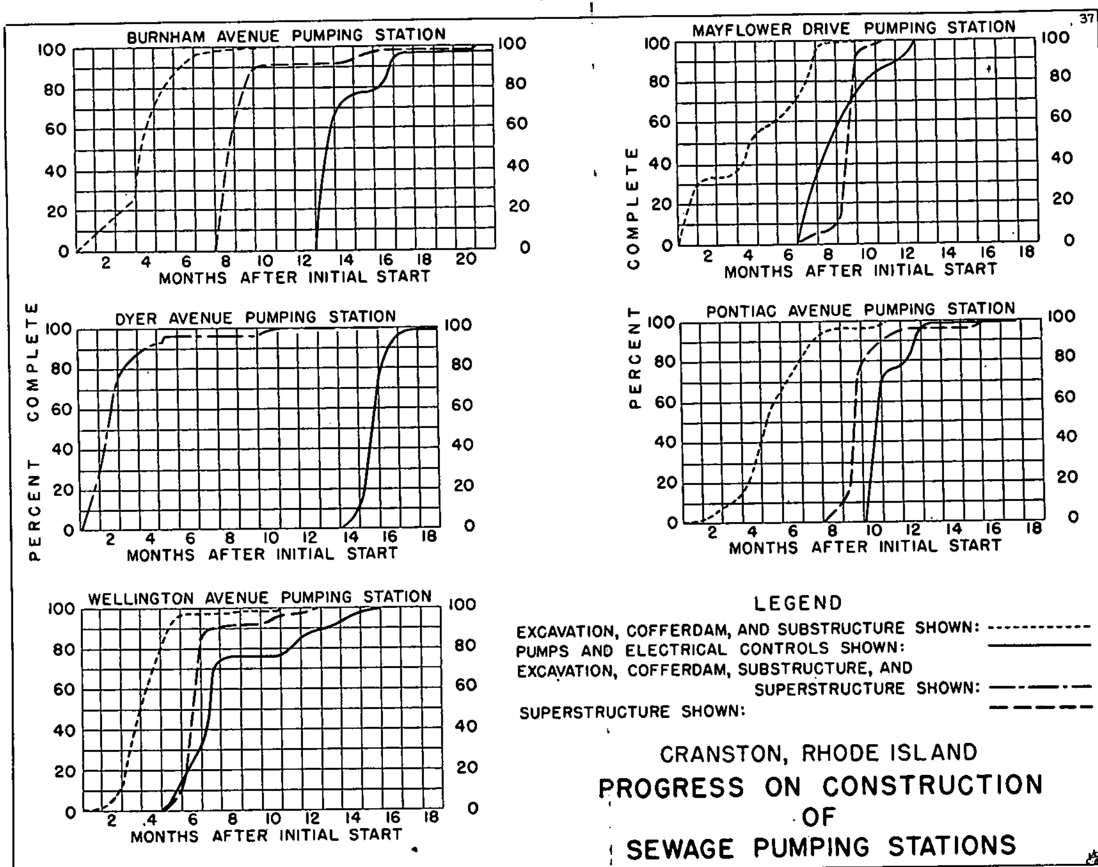

37
BURNHAM AVENUE PUMPING STATION
MONTHS AFTER INITIAL START
MAYFLOWER DRIVE PUMPING STATION
MONTHS AFTER INITIAL START
DYER AVENUE PUMPING STATION
MONTHS AFTER INITIAL START
PONTIAC AVENUE PUMPING STATION
MONTHS AFTER INITIAL START
WELLINGTON AVENUE PUMPING STATION
MONTHS AFTER INITIAL START
PERCENT COMPLETE
LEGEND
EXCAVATION, COFFERDAM, AND SUBSTRUCTURE SHOWN:
PUMPS AND ELECTRICAL CONTROLS SHOWN:
EXCAVATION, COFFERDAM, SUBSTRUCTURE, AND SUPERSTRUCTURE SHOWN:
SUPERSTRUCTURE SHOWN:
CRANSTON, RHODE ISLAND
PROGRESS ON CONSTRUCTION OF SEWAGE PUMPING STATIONS

FIG. 16.

TABLE VI
Cranston, Rhode Island
Pumping Stations—Sizes and Costs

Name of Station	Substructure				Superstructure				Furnishing and Installing Pumping Equipment & Electrical Controls (a)			
	Length	Width	Depth	Cost	Length	Width	Height	Cost	Number of Pumps	Normal Capacity Each Pump G.P.M.	Normal Pumping Head One Pump Operating	Cost
Bay St.	18′3″	13′6″	18′4″	(b)	13′0″	7′4″	7′1″	(b)	2	300(i)	45	$6,167.14
Burnham Ave.	25′10″	24′0″	27′0″	(c) $21,237.66	22′8″	16′0″	9′0″	$3,925.14	2	2,000(i)	53	10,594.57
Dyer Ave.	23′0″	18′0″	23′2″	(d) (e) 23,648.62	18′0″	8′0″	9′0″	(f) 2,574.74	2	600(i)	47	6,559.95
Mayflower Drive	25′10″	24′0″	25′6″	(c) 44,531.82	22′8″	16′0″	9′0″	4,878.00	2	3,000(i)	35	11,867.38
Pontiac Ave.	41′0″	34′6″	32′8″	(c) 50,293.63	19′0″	14′0″	9′0″	(g) 7,529.72	2 2	3,000(h) 3,500(i)	40 41	24,686.83
Sheldon St.	19′4″	14′4″	25′2″	(b)	19′0″	14′0″	9′0″	(b)	2	400(i)	49	6,593.44
Wellington Ave.	25′10″	24′0″	23′0″	(c) 26,112.19	22′8″	16′0″	9′0″	3,912.15	2	2,000(i)	39	8,448.86

(a) Includes all piping and wiring for the stations.
(b) Not yet built.
(c) Includes grading.
(d) Includes cost of superstructure.
(e) Includes grading and fencing.
(f) Includes only miscellaneous metal work and heating and ventilating.
(g) Includes more expensive heating and ventilation provisions than other stations.
(h) Variable Speed Unit.
(i) Constant Speed Unit

dams and grading, has been about 9 months to 10 months. The time for completing superstructure contracts has ranged from 4½ months to about 9 months and the time for installing pumping equipment, electrical controls and their appurtenances has ranged from about 4 months to 10 months. Fig. 16 indicates the progress made in constructing the several pumping stations. Table VI is a summary giving dimensions of the several pumping station structures, sizes of pumping units, and their costs.

Operation and Maintenance of Pumping Stations

The force for operating and maintaining the pumping stations includes five men; namely, a chief operator, three pump operators, and one laborer.

The yearly pay roll for the force operating the pumping stations, based on an average working day, and six days per week, is about $10,000.

The duties of the pumping station force are to operate the pumping station equipment and keep it in repair, and to keep the pumping stations and grounds clean and presentable. The Chief Operator keeps records of the operations of the pumping stations from which a continuous record of the efficiency of the pumping equipment may be kept. The records show finally the electric power consumed each month at each pumping station per million gallons pumpage against one foot of net head.

The electric power consumption per million gallons pumped against one foot of head amounts to about 6 kilowatt-hours.

THE SEWAGE TREATMENT WORKS

The sewage treatment works includes units for primary treatment to remove grit, grease and settleable solids; units for secondary treatment by the activated sludge process; units for disposal of sludge by digestion, vacuum filtration and incineration; and an operating building.

Design of Sewage Treatment Works

The sewage treatment works is designed for the estimated rates of sewage flow in 1950; namely, an average daily rate of 5.5 million

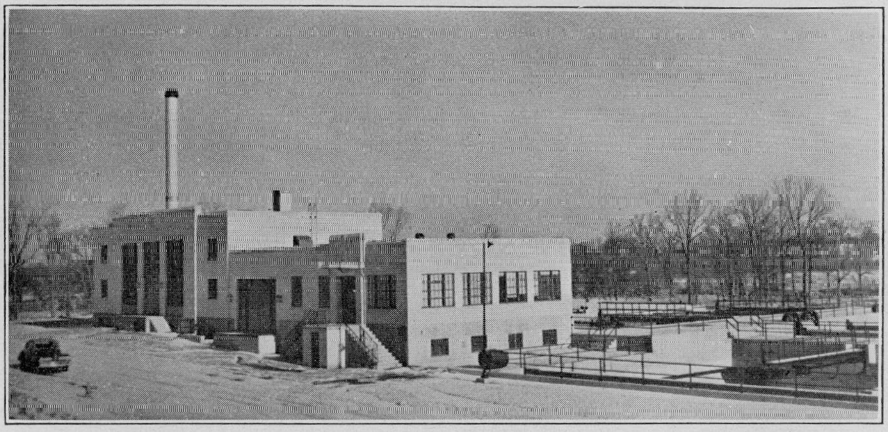


FIG. 17.—FRONT VIEW OF OPERATING BUILDING AT SEWAGE TREATMENT WORKS.

FIG. 18.—AERATION TANKS AT SEWAGE TREATMENT WORKS WITH OPERATING BUILDING AND SLUDGE DIGESTION TANKS IN THE BACKGROUND.

gallons per day and a maximum daily rate of 7.67 million gallons per day. Some of the units are estimated to be adequate for 1970.

Fig. 19a shows the arrangement of the several units which comprise the treatment works and Fig. 19b is a flow diagram indicating the normal operating sequence for the treatment works.

The sewage is delivered from Pontiac Avenue pumping station through about 3,000 feet of 24-inch force main sewer to the treatment works.

Grit Removal Unit. Sewage first enters the grit removal unit where grit, heavy fruit seeds, coffee grounds, some brewery mash and other relatively heavy solids are separated from the liquids by sedimentation. This unit is a shallow concrete basin about 18 feet across with an effective depth of about 1 foot 3 inches below the crest of the overflow weir. The mechanical equipment of the unit includes a revolving detritor 18 feet in diameter driven by electric motor, a reciprocating raking device and a propeller type pump. Sewage entering this unit is distributed from a tapered entrance channel by adjustable deflectors to produce a uniform flow directly across the sedimentation compartment to an overflow weir at the opposite side. Grit and other solids are mechanically raked from a sump up an inclined cleaning channel and removed for disposal. Stagnant sewage in the cleaning channel is pumped back into the stream of incoming sewage.

A by-pass arrangement is provided around this unit.

Comminution Unit. The sewage next passes through a comminution unit, which consists of two channels, each about 5 feet wide and 5½ feet deep. In one channel there is installed a 25-inch comminutor mechanism and in the other channel, an inclined fixed bar screen with 1½ inch clear openings. The comminutor cuts and shreds the sewage solids, thereby reducing them to a size which will pass through ⅜-inch wide slots. Provisions are made for installing a second comminutor mechanism in the future to replace the fixed bar screen.

Master Venturi Meter. The master Venturi meter measures all sewage which passes through the treatment works. It is installed in a concrete chamber about 24 feet long by 8 feet wide by 12 feet deep. The accurate capacity of the meter ranges from 1.5 million gallons per day (M.G.D.) to 12 M.G.D. There is a connection whereby the sewage may be dosed with chlorine at the outlet end of the meter, just before entering the grease removal unit.

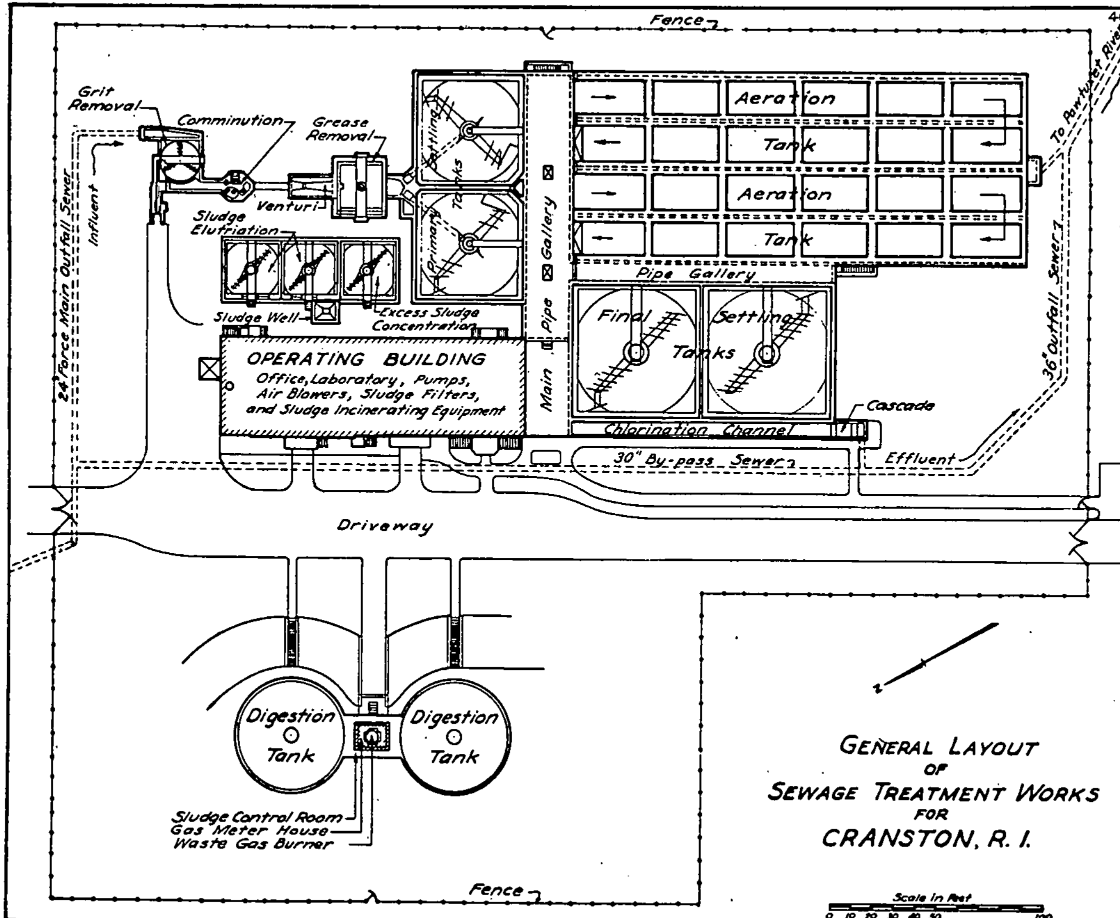

Fence
Grit Removal
Comminution
Grease Removal
Venturi
Sludge Elutriation
Primary Settling Tanks
Main Pipe Gallery
Aeration Tank
Aeration Tank
To Pawtuxet River
Pipe Gallery
Final Settling Tanks
Sludge Well
Excess Sludge Concentration
OPERATING BUILDING
Office, Laboratory, Pumps,
Air Blowers, Sludge Filters,
and Sludge Incinerating Equipment
Chlorination Channel
Cascade
36" Outfall Sewer
Effluent
30" By-pass Sewer
24" Force Main Outfall Sewer
Influent
Driveway
Digestion Tank
Digestion Tank
Sludge Control Room
Gas Meter House
Waste Gas Burner
Fence
GENERAL LAYOUT
OF
SEWAGE TREATMENT WORKS
FOR
CRANSTON, R. I.
Scale in Feet
0 10 20 30 40 50 100

FIG. 19a.

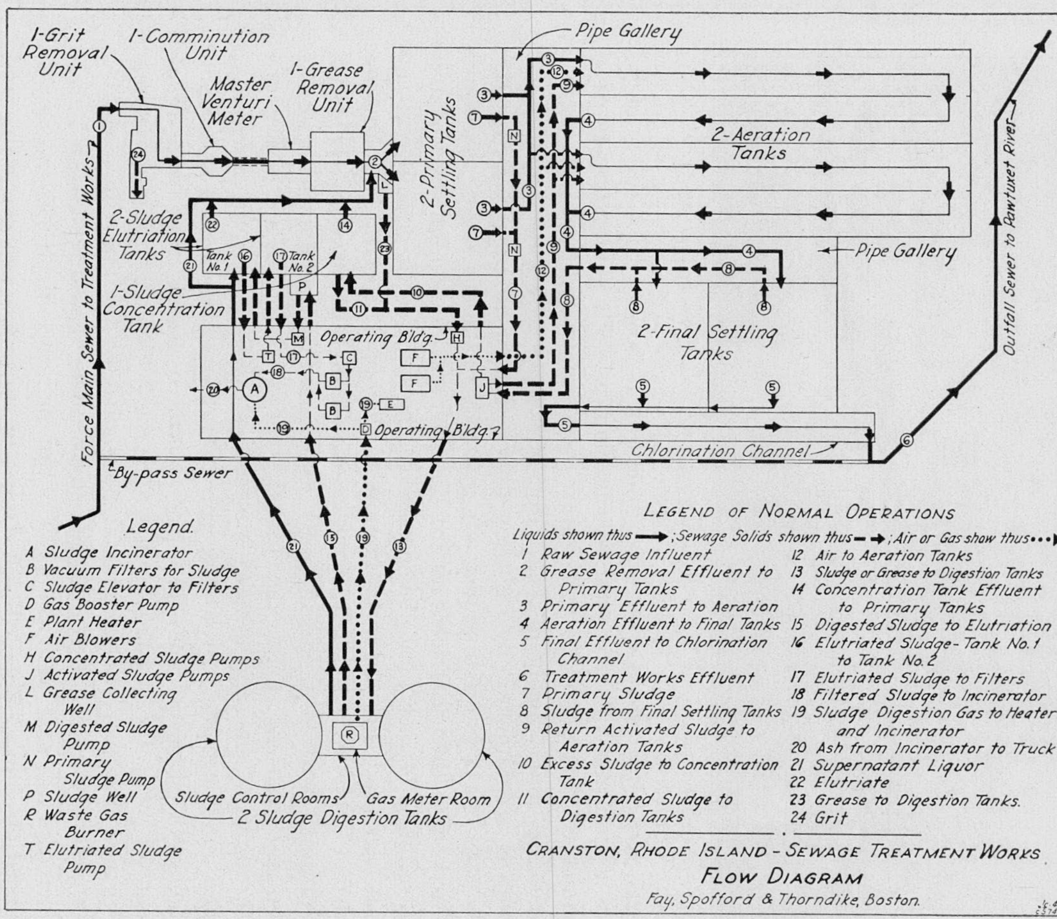

1-Grit Removal Unit
1-Comminution Unit
Master Venturi Meter
1-Grease Removal Unit
Pipe Gallery
2-Primary Settling Tanks
2-Aeration Tanks
Pipe Gallery
2-Sludge Elutriation Tanks
Tank No. 1
Tank No. 2
1-Sludge Concentration Tank
Operating B'ldg.
2-Final Settling Tanks
Chlorination Channel
Outfall Sewer to Pawtuxet River
Force Main Sewer to Treatment Works
By-pass Sewer
Sludge Control Rooms
Gas Meter Room
2 Sludge Digestion Tanks
Legend
A Sludge Incinerator
B Vacuum Filters for Sludge
C Sludge Elevator to Filters
D Gas Booster Pump
E Plant Heater
F Air Blowers
H Concentrated Sludge Pumps
J Activated Sludge Pumps
L Grease Collecting Well
M Digested Sludge Pump
N Primary Sludge Pump
P Sludge Well
R Waste Gas Burner
T Elutriated Sludge Pump
Legend of Normal Operations
Liquids shown thus ; Sewage Solids shown thus ; Air or Gas show thus
1 Raw Sewage Influent
2 Grease Removal Effluent to Primary Tanks
3 Primary Effluent to Aeration
4 Aeration Effluent to Final Tanks
5 Final Effluent to Chlorination Channel
6 Treatment Works Effluent
7 Primary Sludge
8 Sludge from Final Settling Tanks
9 Return Activated Sludge to Aeration Tanks
10 Excess Sludge to Concentration Tank
11 Concentrated Sludge to Digestion Tanks
12 Air to Aeration Tanks
13 Sludge or Grease to Digestion Tanks
14 Concentration Tank Effluent to Primary Tanks
15 Digested Sludge to Elutriation
16 Elutriated Sludge - Tank No. 1 to Tank No. 2
17 Elutriated Sludge to Filters
18 Filtered Sludge to Incinerator
19 Sludge Digestion Gas to Heater and Incinerator
20 Ash from Incinerator to Truck
21 Supernatant Liquor
22 Elutriate
23 Grease to Digestion Tanks.
24 Grit
Cranston, Rhode Island - Sewage Treatment Works
Flow Diagram
Fay, Spofford & Thorndike, Boston.

Fig. 19b.

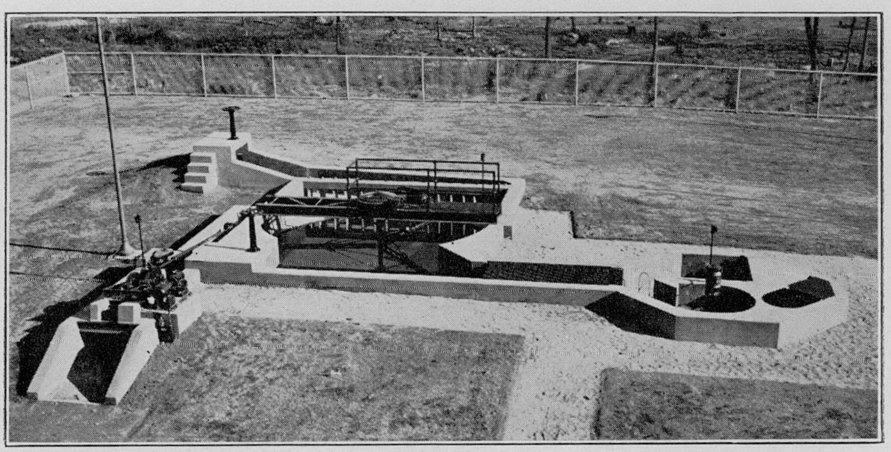


FIG. 20.—GRIT REMOVAL AND COMMINUTION UNITS AT SEWAGE TREATMENT WORKS.

Grease Removal Unit. A single unit is provided for the removal of grease and fats from the sewage liquids. The unit consists of a concrete tank about 20 feet square with side-water depth of 10 feet 4 inches and a mechanical flotation device. Separation of grease and fats is accomplished by diffusing finely divided air particles over the bottom of the unit which in rising upwards to the surface of the liquid carry with them particles of grease and fats. Sewage enters the unit through a 24-inch pipe placed near the bottom of the chamber at the inlet end and travels across the tank to the opposite end. The flotation device includes a downdraft tube located in the center of the tank, equipped with a non-clog screw type pump impeller which draws liquids from the surface level, and some atmospheric air, downward through the tube and forces it out across the tank bottom. A circular non-metallic baffle surrounding the downdraft tube extends above and below the flow line and keeps the separated grease from being recirculated with the sewage liquids. Grease which accumulates on the surface is drawn into troughs at both sides of the tank by means of revolving spiral rubber squeegee strips. The separated grease is collected in a grease well whence it is pumped periodically to the sludge digestion tanks. The effluent from the unit passes over weirs and thence to primary settling tanks.

A by-pass pipe is provided around this unit.

Primary Settling Tanks. There are two primary settling tanks.

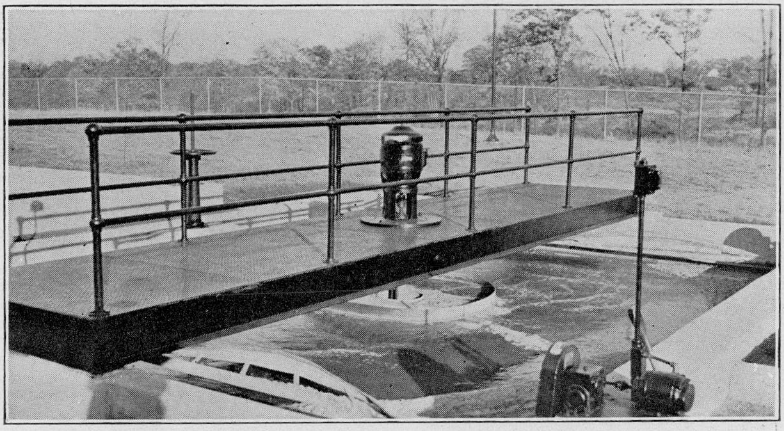


FIG. 21.—GREASE REMOVAL UNIT AT SEWAGE TREATMENT WORKS.

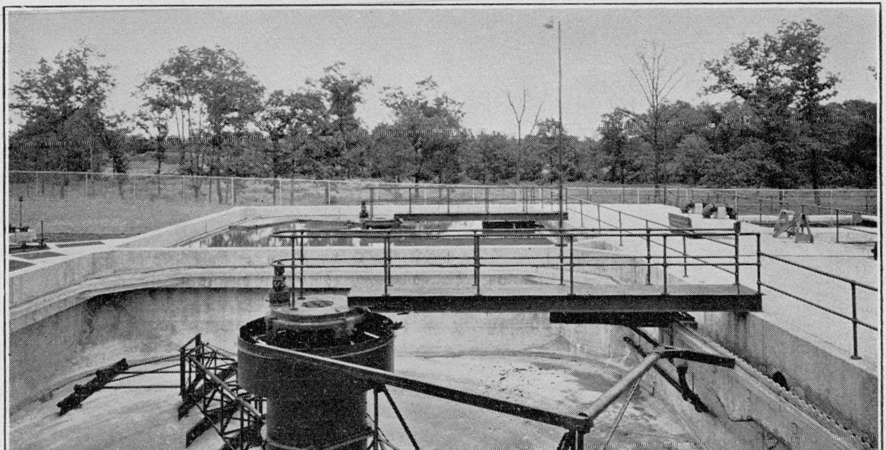


FIG. 22.—PRIMARY SETTLING TANKS AT SEWAGE TREATMENT WORKS.

In these tanks the heavier organic solids are separated from the liquids by sedimentation, and accumulate as sludge on the bottoms of the tanks. Each tank is of concrete, 50 feet square, with side-water depth of 9 feet 1 inch and bottom sloping toward a central sump, the bottom slope being one inch per foot. The mechanical equipment of each tank is a revolving center drive clarifier with two bottom scraper arms and a skimmer arm at flow line level. Sewage enters the tanks at the bottom through a cast iron pipe which

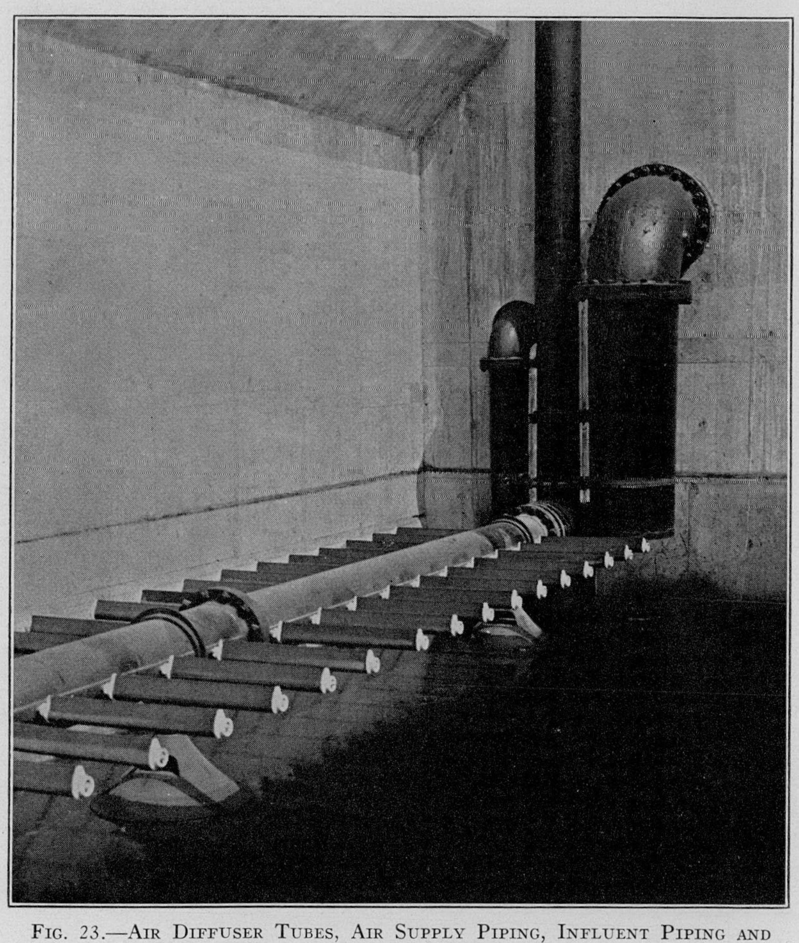


FIG. 23.—AIR DIFFUSER TUBES, AIR SUPPLY PIPING, INFLUENT PIPING AND RETURN SLUDGE PIPING IN AERATION TANKS AT SEWAGE TREATMENT WORKS.

discharges at a central influent well. The effluent flows over multiple V-notched weir plates, placed along all four sides of each tank. The sludge is pumped from the tanks each day to sludge digestion tanks.

Aeration Tanks. From the primary settling tanks the effluent passes to the aeration tanks. There are two aeration tanks in which the sewage liquids are intimately mixed with returned activated sludge by means of compressed air discharged through air diffuser tubes placed near the tank bottoms. The process in the aeration tanks is intended to oxidize the organic material and to aid in clarifying the liquids. Each tank is about 210 feet long by 41 feet wide with side-water depth of 12 feet, the entire width being divided into two channels (or passes), each 20 feet wide, extending the full length of the tank, so that the total effective length of travel through each tank is approximately 420 feet, down one channel and back the other. Each tank is equipped with 338 air diffuser tubes, of tear drop shape, each 2 feet long. The tubes are spaced for tapered aeration and connected into a cast iron header pipe; they are set in place with the thin edge of the tube upward. The primary tank effluent, the returned activated sludge and the air supply all enter the aeration tanks near one corner at the inlet end. The inflow to each tank is near the bottom of one channel and the effluent passes over a weir crest at the outlet end of the other channel.

Air Blowers. Compressed air for the aeration tanks is furnished by two rotary-type positive displacement blowers, each having maximum capacity of about 4,000 cubic feet per minute. Each blower has two sets of rotary impellers, one set having a capacity of 1,500 cubic feet per minute and the other set 2,500 cubic feet per minute capacity, or a total of 4,000 cubic feet per minute capacity when operating together. The two blowers have flexible capacity ranging from 1,500 to 8,000 cubic feet of air per minute. The blowers are driven by 150 horsepower 4,000 volt, synchronous motors with remote control, and are installed in the basement of the operating building.

Final Settling Tanks. The effluent from the aeration tanks passes to final settling tanks which, by sedimentation, separate the organic solids from the effluent of the aeration tanks. There are two final settling tanks, each 60 feet square, with side-water depths of about 9 feet 10 inches and bottom sloping toward a central sludge sump. The pitch of the bottoms is 2 inches per foot. Mechanical equipment of the

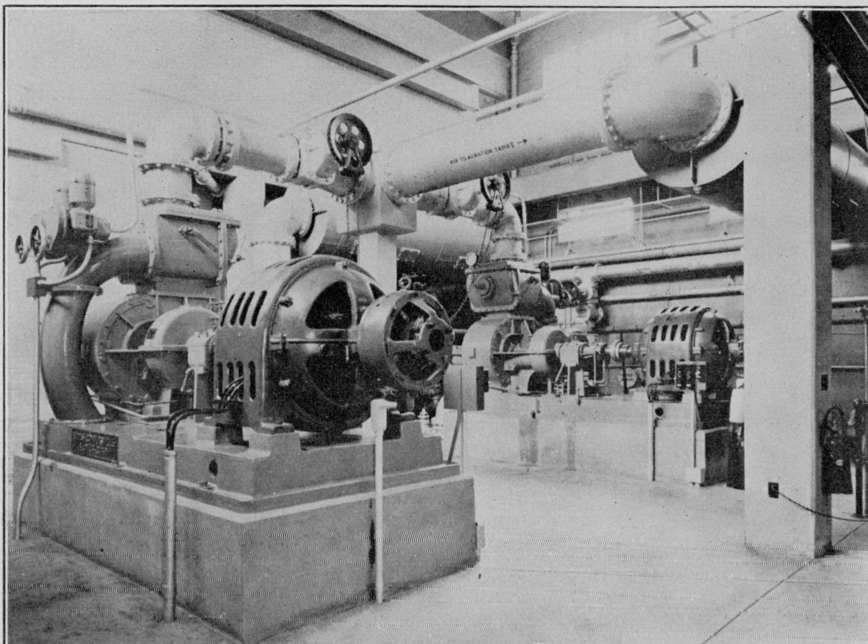


FIG. 24.—ROTARY TYPE BLOWERS WHICH FURNISH COMPRESSED AIR FOR AERATION TANKS AT SEWAGE TREATMENT WORKS.

tanks consists of revolving center drive clarifiers with two bottom rake arms and scraper blades. Sewage enters the tanks through an influent trough discharging at flow line level at the center of the tanks; and the effluent flows over multiple V-notched weir plates placed along all four sides of the tanks. Sludge collected in these tanks furnishes the return activated sludge for the aeration tanks. Excess sludge is thickened in a sludge concentration tank and then pumped to the sludge digestion tanks.

Chlorination Channel. The effluent from the final settling tanks flows through a chlorination channel where it may be disinfected before passing from the treatment works into the outfall sewer, and thence to the Pawtuxet River. The chlorination channel is 121½ feet long by 6 feet 6 inches wide and has about 5 feet or more effective depth; at its outlet end, it has a cascade about 16 feet long and 6 feet 6 inches wide. Provisions are made for applying liquid chlorine to the treatment works effluent at the upper end of the chlorination channel. A vacuum type chlorinator with manual control is provided, with capacity range of 20 to 400 lbs. per 24 hours.

Pipe Galleries. The major piping which conveys the effluents between the primary settling tanks, aeration tanks, and final settling tanks, and also the compressed air piping, the return activated sludge piping and other miscellaneous piping is housed in two pipe galleries; a main pipe gallery approximately 162 feet long by 20 feet wide and 18 feet high, and a secondary pipe gallery, which is approximately 123 feet long by 8 feet wide by 16 feet high. Provisions for sampling sludge from the primary settling tanks and final settling tanks also are installed in the pipe galleries.

Sludge Concentration Tank. Excess activated sludge from the final settling tanks is thickened in a sludge concentration tank to reduce its moisture content. This tank is 26 feet square with side-water depth of 9 feet 10 inches and bottom sloping to a central sludge pocket. The bottom slope is one inch per foot. The tank is equipped with a revolving center drive sludge thickener mechanism consisting of two bottom arms with steel blades arranged for moving the sludge on the tank bottom and scraping it into the sludge pocket. Each arm of the sludge thickener mechanism is equipped with vertical pickets which have their tops about 3 feet below flow line level of the tank.

Excess activated sludge enters the tank through a pipe discharging into a central cylindrical influent well at a level about 2 feet 4 inches below the flow line and passes beneath the influent well baffle plate and out into the tank. Liquid effluent from the tank overflows multiple V-notched weir plates placed on all four sides of the tank and is again mixed with the sewage liquids entering the primary settling tanks. Thickened sludge collected at the bottom of the tank in the sludge pocket is pumped to the sludge digestion tanks.

Sludge Digestion Tanks. There are two sludge digestion tanks in which anaerobic digestion of the sludge is accomplished, whereby the sludge is converted into an inoffensive sludge residue above which there is developed a layer of supernatant liquor. The digestive action taking place also creates gases which may be burned. These gases generally consist of methane, carbon dioxide and hydrogen sulphide.

Each sludge digestion tank is 50 feet in diameter with effective side depths of 26 feet and effective center depths of 31.5 feet. The

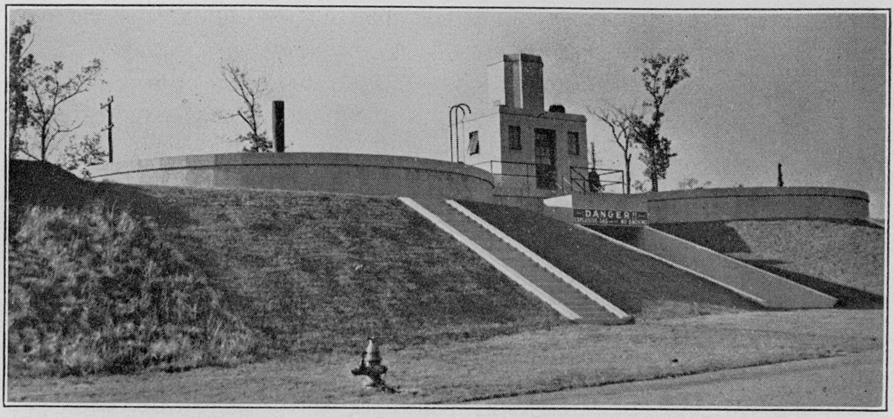


FIG. 25.—SLUDGE DIGESTION TANKS AT SEWAGE TREATMENT WORKS.

bottoms of the tanks slope toward the centers at a pitch of about 2½ inches per foot. Each tank is equipped with a floating cover for collecting the gas produced. The tanks are heated by eight 4-inch lines of hot water piping placed around the inside perimeter of each tank. Heating provided for the tanks is estimated to be ample to maintain sludge temperatures up to 95° F. Sludge is discharged into the tanks through a pipe line which enters each tank at one point in the vertical wall about 10 feet above the bottom of the wall. Digested sludge is withdrawn from the tanks through pipes which extend from a sump at the center of each tank. Supernatant liquor is withdrawn at various levels by means of pipes through the vertical walls of the tanks, these pipes being placed to accommodate different depths of sludge and different levels of supernatant liquor. Gas collected under the floating covers of the tanks is used either for heating the tanks and operating building, for incineration of the sludge, or is burned as waste gas if in excess of the quantity needed.

The sludge digestion tanks may be operated either in series or parallel. To date operation of the tanks in series appears to result in about 10 per cent greater gas production than operation of the tanks singly. The tanks have capacity for a sludge digestion period of 30 days and storage capacity for 10 days, during the average daily sewage flow conditions of 1950.

Between the two sludge digestion tanks there is a building structure which comprises two sludge control rooms, one above the other, a gas meter room and a waste gas burner. The sludge control rooms house piping and valves for controlling the flow of sludge into and out from the sludge digestion tanks and flow between the two tanks. One sludge control room also houses piping and valves for controlling the discharge of supernatant liquor from the tanks. Facilities are provided in one of the sludge control rooms for sampling sludge and supernatant liquor. The gas meter room houses facilities for measuring and controlling the flow of gas produced. Excess gas is burned in the waste gas burner, which is enclosed by a chimney located on the roof of the gas meter room. The chimney is octagonal in shape, 6 feet wide inside and about 10 feet high above the roof level. Various precautions have been taken to guard against explosion in either the gas meter room or sludge control rooms. Explosion-proof electric conduits and fixtures are used in the building and the electric switches are placed outside. There is natural ventilation and also artificial ventilation, automatically controlled. Gas piping is fitted with flame traps and flame cells as necessary.

Sludge is withdrawn from the sludge digestion tanks by gravity through an 8-inch cast iron pipe into a sludge storage well whence it is pumped to sludge elutriation tanks. Observations of friction loss in the new 8-inch sludge pipe indicated a friction coefficient of $C=120$ for Hazen and Williams' formula, with sludge having about 5.0 per cent solids content.

Sludge Elutriation Tanks. The digested sludge is washed by means of a counter-current elutriation process in two elutriation tanks for the purpose of reducing the ferric chloride needed to produce the best dewatering results from vacuum filtration. Upwards of 50 per cent saving in the use of ferric chloride is estimated to date from the elutriation process. Each sludge elutriation tank is 26 feet square with side-water depth of about 10 to 11 feet, and sloping bottoms, the bottom slopes being one inch per foot. Each tank is equipped with a revolving center drive sludge thickener mechanism similar to that used in the sludge concentration tank and each mechanism is fitted with bottom scrapers and vertical pickets. In the elutriation tanks, the digested sludge is thoroughly washed by mixing it and stirring it with clean water and elutriate in the proportion of about 3 parts water to one part sludge. The elutriation tanks are operated in series. The

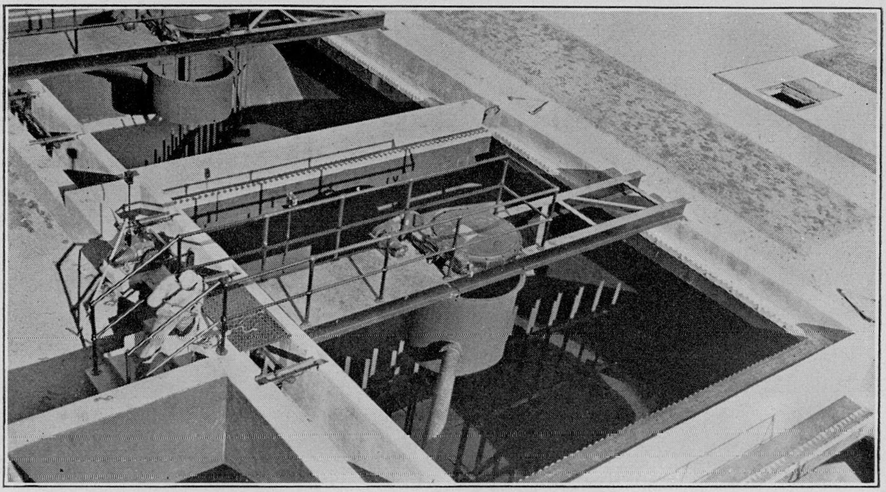


Fig. 26.—Sludge Elutriation Tanks at Sewage Treatment Works.

sludge is pumped from the sludge storage well to the first elutriation tank where mixing with elutriate liquid from the second elutriation tank takes place in a mixing channel; thence the sludge flows through a pipe to a central influent well. The effluent liquid from the elutriation tanks flows over multiple V-notched weir plates extending along three sides of the tanks. Effluent liquids from the first elutriation tank are discharged into the sewage entering the primary settling tanks and again subjected to the sewage treatment process. The elutriated sludge collects at the bottom of the elutriation tanks. Elutriated sludge from the first tank is pumped to the second, emptying first into a mixing channel where it is stirred with entering clean water. The sludge is withdrawn from the second tank by gravity to a bucket elevator which raises it from the basement of the operating building to the first floor level where the vacuum filters are located. The sludge bucket elevator is enclosed in a concrete sludge well extending between the basement and the first floor level.

Vacuum Filters for Sludge. The sludge is discharged from the bucket elevator and delivered to a sludge mixing tank and agitator where liquid ferric chloride is added. The sludge mixture then passes to the vacuum filters.

There are two vacuum filters, of the rotary drum type, for

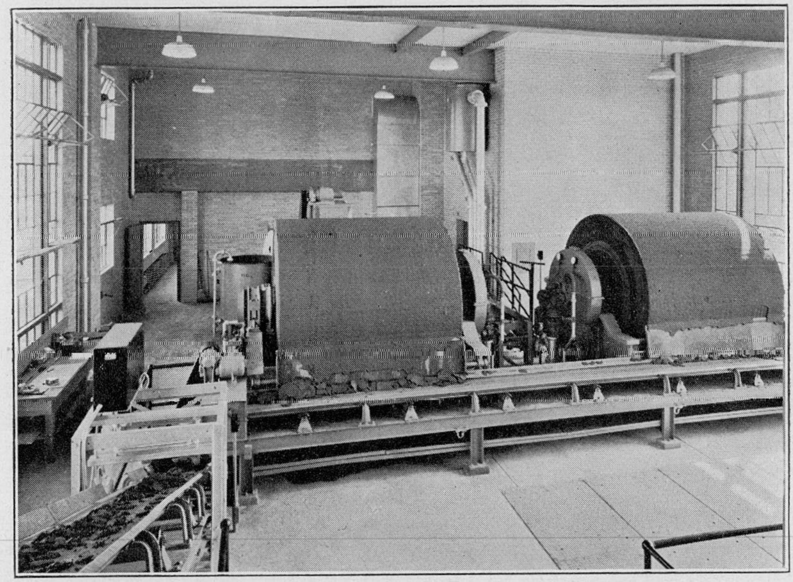


FIG. 27.—VACUUM FILTERS FOR SLUDGE AT SEWAGE TREATMENT WORKS.

dewatering the sludge by vacuum. Each filter consists of a drum about 8 feet in diameter by 8 feet long with effective filtering area of about 200 square feet. Each drum, in revolving, rotates through a trough beneath its axis. The troughs contain the sludge mixture; and vacuum maintained on the inside of the drum causes the sludge mixture to adhere to the outside of the drum and dewatering of the sludge to be accomplished. Just before one complete revolution of the sludge on the filter drum has taken place, the sludge cake is removed from the drum by means of air pressure and a discharge scraper, the scraper being so located that the sludge cake will be removed from the drum below the drum center line. The sludge cake removed from the filter drops upon a belt conveyor and is carried over a continuous weighing apparatus which indicates and records the weight of the sludge. From the weighing apparatus the belt conveyor carries the sludge to the incinerator, or if desired discharges it into a hopper from which the sludge may be discharged directly into trucks outside the building. The filtrate liquids from the two vacuum filters are pumped into the digested sludge storage well, whence they eventually pass through the elutriation process.

Sludge Incinerator. The final step in treatment of the sewage sludge is accomplished by incineration after which the resultant ash is disposed of for filling in the vicinity of the plant. The sludge incinerator is a circular, multiple hearth type, having six hearths. It is about 14 feet outside diameter and about 18 feet in height. It is arranged to be fired either with sludge digestion gas or fuel oil. The resultant ash is sterile and contains not over 4 per cent of combustible material. The ash is discharged by means of a bucket elevator and screw conveyor into an elevated ash bin outside the building from which the ash is emptied by gravity into trucks for removal. The incinerator stack is about 3 feet in diameter inside and about 50 feet high above the center line of the incinerator gas outlet. The stack is lined with 4½ inch thickness of refractory insulating brick.

Sludge Pumps. Several different types of pumps are used to handle the sludge in the various steps of the sewage treatment process. Primary sludge is pumped by two variable speed scru-peller pumps to the sludge digestion tanks. Activated sludge is pumped by three non-clog vari-speed pumps. Concentrated activated sludge and grease are pumped by two variable speed scru-peller pumps. Digested sludge

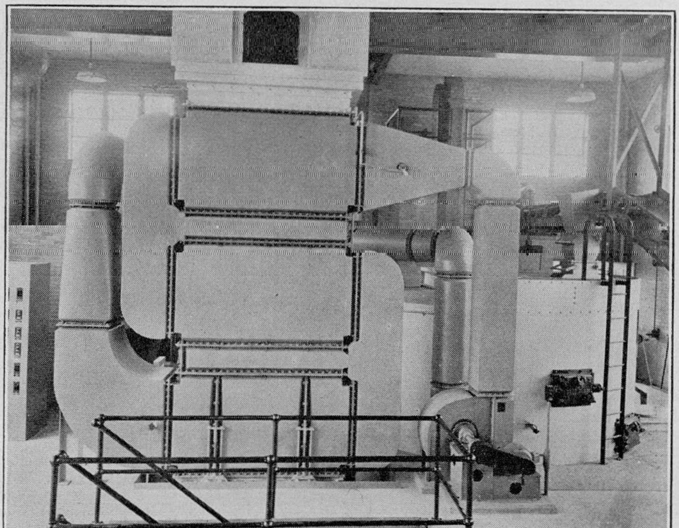


FIG. 28.—SLUDGE INCINERATOR AND PREHEATER AT SEWAGE TREATMENT WORKS.

is pumped by one variable speed plunger type pump. Elutriated sludge is pumped by one variable speed scru-peller pump.

Metering System. A system of metering is provided to assist in the control of plant operations and to afford a complete operating record. Separate measurements are recorded of influent raw sewage—settled sewage delivered to each aeration tank—air supplied to each aeration tank—return activated sludge—excess activated sludge—sludge delivered to the digestion tanks—weight of sludge cake from vacuum filters and volume of gas from sludge digestion.

Plant Water Supply. An auxiliary water supply for the sludge elutriation process was obtained by construction of an infiltration gallery to develop a ground water supply. The infiltration gallery consists of two rows of 12-inch vitrified skip pipe in two-foot lengths. The plant water system includes the infiltration gallery, a water supply pump, a concrete storage reservoir of about 25,000 gallons capacity, a pneumatic water tank, 6 feet diameter by 16 feet long, and a high pressure water pump with air compressor and electrical control apparatus.

Operating Building. The operating building is approximately 45 feet wide and 143 feet long. The building in part consists of a basement and one story superstructure, and in part, a basement and superstructure two stories high. The building has reinforced concrete foun-

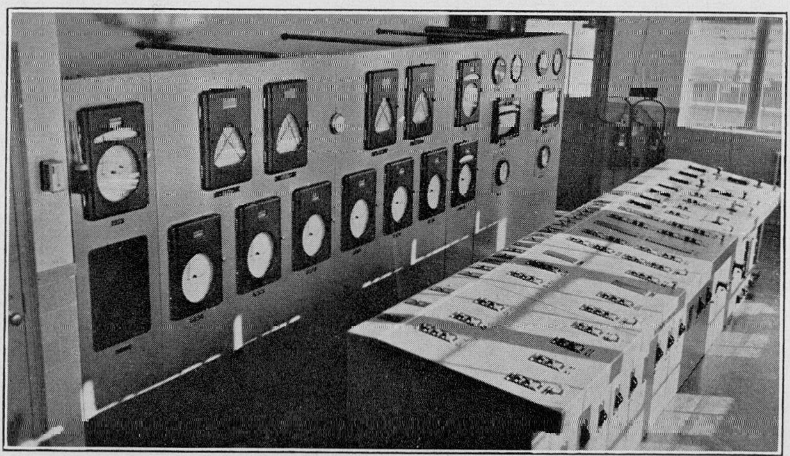


FIG. 29.—ELECTRICAL CONTROL DESK AND INSTRUMENT PANEL IN OPERATING BUILDING AT SEWAGE TREATMENT WORKS.

TABLE VII

CRANSTON, RHODE ISLAND.

SEWAGE TREATMENT WORKS

DIMENSIONS AND DESIGN DATA

Treatment Units	No. Units	Dimensions			Design Data						
		Length	Width	Effective * Depth	Velocity of Flow	Detention Period	Surface Settling Rate Gals. per sq. foot per Day	Weir Discharge Rates Gals. per ft. of Weir per Day	Effective Rate	Sludge Pumping Rates per Pump in % of Sewage Flow.	Remarks
Grit Removal	1	18'	18	(1) 1'-3"	(1) 0.3 f.p.s. (2) 0.5 f.p.s.	(1) 52 sec. (2) 34 sec.					
Comminution	2	25" Comminutor Mechanisms							(1) Head loss not over 8" (3) Head loss not over 15"		Only one mechanical unit installed at outset
Grease Removal	1	20'	20'	10'-4" SWD		(1) 7.7 min. (2) 5.1 min.					
Primary Settling	2	50'	50'	9'-1" SWD		(1) 1.6 hrs. (2) 1.0 hrs.	(1) 1,100 (2) 1,650	(1) 15,300			
Aeration	2	210'	2 Passes of 20' each	12' SWD		(1) 5.1 hrs. with 30% return sludge			0.9 cu. ft. of air per gal. sewage.		
Air Blowers	2								1,500 to 4,000 cu. ft. of air per min. per Blower.		
Final Settling	2	60'	60'	9'-10" SWD		(1) 2.1 hrs., includes 30% return sludge	(1) 1,000, includes 30% return sludge	(1) 11,500			
Chlorination Channel	1	121'-6"	6'-6"	5' SWD		(1) 10± min.					
Chlorinator									20 lbs. to 400 lbs. per 24 hrs.		Manual Control Chlorinator
Digested Sludge Concentration	1	26'	26'	9'-10" SWD							
Sludge Digestion	2	50' Diameter		26' SWD		(1) 30 Days digestion and 10 Days storage					Tanks heated by hot water to 95°F., by 8 coils of 4" pipes around inside perimeter.
Sludge Elutriation	2	26'	26'	Tank No. 1, 9'-10" Tank No. 2, 10'-11"					Wash Water Rate 3 to 1		
Vacuum Filtration	2	8' Long	8' Diameter	200 sq. ft. effective area					Up to 4 lbs. of dry solids per sq. ft. per hour.		
Vacuum Pumps	2								400 cu. ft. per min. at 26" of vacuum		
Ferric Chloride Feeders									$FeCl_3$ Feeders Rate 72 Gals. per hour max.		
Sludge Incineration	1	14'-3" Outside Diameter		About 18' high					1000 lbs. dry solids and 3000 lbs. of water per hour.		Six hearths
Sludge Pumps Primary Tank Sludge	2								150 g.p.m.	(1) to digestion tanks 4%	Variable speed Scru-peller Pumps
Activated Sludge	3								1000 g.p.m.	(1) to aeration tanks 26%	Variable speed non-clog Pumps. One pump is standby.
Concentrated Sludge	2								200 g.p.m.	(1) to digestion tanks 5%	Variable speed Scru-peller Pumps.
Elutriated Sludge	1								100 g.p.m.	(1) to vacuum filters 2.5%	Variable speed Scru-peller Pumps
Digested Sludge	1								70 g.p.m.	(1) to vacuum filters 1.8%	Variable speed Plunger Type Pump.

* To Weir Crest (1) For average daily flow of 1950 = 5.5 m.g.d. (2) For average daily flow of 1970 = 8.3 m.g.d. (3) Maximum hourly flow of 1950 = 10.5 m.g.d. SWD = Side Water Depth.

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dation walls, with brick superstructure. The roof slab is reinforced concrete with tar and gravel roof covering.

The operating building houses an office and laboratory, together with the major items of mechanical equipment which are not installed outside in the individual treatment units. The equipment housed includes air blowers, vacuum filters, incinerator, chlorinator equipment, various pumps and an electrical control desk for operating the plant units. Control of the plant units, except those for digested sludge disposal, is centralized in the control desk. Special effort was made toward obtaining a compact arrangement of the plant units and as a result, practically every outside unit of the entire plant may be seen from the office, in which the control desk is located. The mechanisms of the outside units may be operated at the individual units as well as from the control desk.

Central heating facilities for the office building and for the sludge digestion tanks include a forced circulation closed hot water system. The water is heated and maintained at constant temperature of approximately 180° F. by means of a steel fire tube boiler utilizing either sludge digestion gas or fuel oil.

The design factors used for the several units of the sewage treatment works are given in Table VII; in Table VIII are given the names of the manufacturers of the principal items of mechanical equipment.

Operation of Sewage Treatment Works

The operating force for the sewage treatment works includes eight men; namely, 1 superintendent, 1 chemist, 3 plant operators, 1 filtration and incinerator operator, 1 laborer employed on filters, incinerator and miscellaneous work, and 1 laborer employed on general plant operation. The pay roll of the operating force is about $16,000 per year. The estimated cost for fuel, electricity, chemicals, tools and supplies, laboratory expenses, truck operation and miscellaneous minor expense items is about $15 per million gallons of normal domestic sewage. The total estimated cost of treating normal domestic sewage, including the cost of the operating force as well as the cost of items previously enumerated, is $23 per million gallons, when the treatment works is handling its average daily designed capacity.

The sewage treatment works commenced operation on March 2,

TABLE VIII

CRANSTON, RHODE ISLAND

SEWAGE TREATMENT WORKS EQUIPMENT

Manufacturers of Mechanical Equipment

Treatment Units	Equipment	Manufacturer
Grit Removal	Detritor Grit Removal Mechanism Organic Return Pump	The Dorr Company, Inc.
Comminution	Comminutor	Chicago Pump Co.
Venturi Chamber	Venturi Meter	Builders-Providence Inc.
Grease Removal	Grease Flotation Unit	The American Well Works
	Grease Skimmer	The American Well Works
Primary Settling Tanks	Clarifier	The Dorr Company, Inc.
Aeration Tanks	Blowers	Roots Connersville Blower Corp.
	Air Filters	American Air Filter Company, Inc.
	Silencers	The Maxim Silencer Co.
	Diffuser Tubes	National Carbon Co.
Final Settling Tanks	Clarifier	The Dorr Company, Inc.
Chlorination Channel	Chlorinator	Wallace & Tiernan Co., Inc.
Sludge Digestion Tanks	Downes Floating Covers	Pacific Flush Tank Company
Sludge Control Building	Waste Gas Burner	Pacific Flush Tank Company
Sludge Tanks (Elutriation and Concentration)	Swing Mixer	Ralph B. Carter Co.
	Sludge Thickener	The Dorr Company, Inc.
Operating Building	Vacuum Filters	The Eimco Corporation
	Incinerator	Nichols Engineering & Research Corp.
	Boiler	Fitzgibbons Boiler Co., Inc.
	Oil and Gas Burner	Ray Oil Burner Co.
	Gas Booster Pump	Roots Connersville Blower Corp.
	Laboratory Equipment	E. H. Sheldon & Co.
	Electrical Control Boards	General Electric Co.
	Electrical Control Desk	General Electric Co.
	Sludge Pumps	Chicago Pump Co.
	Venturi Meters	Builders-Providence Inc.
	Recording Instruments	Brown Instrument Co.

1942, receiving at that time domestic sewage only. At the beginning there were about 200 active service connections. The number of active service connections increased steadily at a rate of about 46 per week and by the end of 1942, there were nearly 2,100 active services and the total sewage flow amounted to about 2,400,000 gallons per day, consisting of about 415,000 gallons of infiltration (or ground water leakage), about 500,000 gallons of domestic sewage, about 160,000 gallons of untreated wastes from the Narragansett Brewery and about 1,325,000 gallons of settled wastes from the Cranston Print Works.

By the end of May, all units of the treatment works were in operation and good results were being accomplished. At this time, there were about 1,150 active service connections and an average daily sewage flow of nearly 400,000 gallons of domestic sewage and infiltration. Average operating results for the month of May indicated about 87 per cent reduction in the biochemical oxygen demand (B.O.D.) of the sewage and about 85 to 90 per cent reduction of suspended solids. The raw sewage entering the treatment works was alkaline, having a pH of about 7.5; it was devoid of dissolved oxygen. During the period from May 6 to May 18, activated sludge was developed in the aeration tanks. Primary sludge was pumped to the digestion tanks practically from the outset and gas production at the digestion tanks developed in about five weeks after the sludge was first delivered to the tanks; gas production was at the rate of about 1.3 cu. ft. per capita per day. The chemical reaction at the sludge digestion tanks was kept neutral or slightly alkaline by the use of lime as necessary. Prior to pumping any sludge into a sludge digestion tank, the tank was filled with water and its temperature was maintained in the neighborhood of 80° to 85° F. for about one month.

In June wastes from Narragansett Brewery were admitted to the sewer system, without approval of the Engineer, and difficulties in the operation of the sewage treatment works developed promptly thereafter. Initial tests of the brewery wastes, made by a former sewage treatment works chemist, had indicated a high B.O.D. amounting to about 350 parts per million but later analyses have shown an excessively high B.O.D. amounting to from 1,500 to 8,500 parts per million, and averaging nearly 4,000 parts per million throughout the day. With the admission of brewery wastes, the sewage reaction immediately became acid, pH about 6.4; the B.O.D. of the incoming sewage increased from less than 200 parts per million to nearly 900 parts per million and the suspended solids reached nearly 650 parts per million; dissolved oxygen could not be maintained in the aeration tanks and the activated sludge became septic with resultant offensive odors. Operation of the final settling tanks was eliminated. Abnormally large volumes of sludge gas were created in the sludge digestion tanks amounting to as much as 8 cubic feet per capita. The brewery wastes never should have been admitted to the sewer system without pre-treatment to correct the excessively high B.O.D. Although the volume of brewery wastes was equal only to the volume of sewage from 1,600 people, the organic load imposed on the sewage treatment works by the brewery wastes, as indicated by the B.O.D., was equal to the normal sewage load from 32,000 people.

The settled wastes from Cranston Print Works were admitted to the sewer system early in August and the pH of the incoming sewage again became alkaline at about 7.2. The B.O.D. of the raw sewage dropped to about 600 parts per million and the suspended solids of the incoming raw sewage dropped to about 300 parts per million. At that time the final settling tanks were not being operated and consequently the treatment was no longer the activated sludge process. Gas production in the digestion tanks dropped to 6 cubic feet per capita per day and continued to drop until it had reduced to about 2.5 cubic feet per capita at the end of 1942. The B.O.D. of the Print Works waste entering the sewer system is about 300 parts per million and the pH about 10.8.

Vacuum filtration and incineration of the sludge have been satisfactorily accomplished and some demand has developed for use of the sludge cake from the vacuum filters as fertilizer. In fact, considerable sludge cake has been sold at 50 cents per cubic yard.

Construction of Sewage Treatment Works

The site of the treatment works originally was thickly covered with scrub growth and numerous large trees, many of which had been uprooted by the hurricane of 1938. The geological formation at the site was mostly sand and gravel with ground water level above the deeper excavations.

Excavation was done largely by tractors hauling drag scrapers. A limited amount of excavation was handled by bulldozer and the footings were excavated by mobile crane or by hand. About 4,000 cubic yards of loam and top soil were removed and stored, and later used for top dressing the finished grading. The operating building, pipe galleries, aeration tanks, final settling tanks and sludge digestion tanks were built mostly on undisturbed natural material, while the primary settling tanks, grease removal tank, Venturi meter chamber, grit removal unit, and the sludge concentration and sludge elutriation tanks were built on filled material ranging from a few feet in depth at the primary settling tanks to about 18 feet in depth at the grit removal unit. Excavated material from the sludge digestion tanks site was used largely for the filling on which the several units were built. The filling material was placed in layers and compacted by bulldozers with drag scrapers. All filling material was placed in the late fall and allowed to settle during the winter and spring before structures were built upon it during the following summer. Material for filling and grading around the sludge digestion tanks and the several other units was obtained largely from necessary excavation along the approach roadway. The total excavation amounted to about 51,000 cubic yards.

Dewatering of the natural formation in which the deeper excavations were made was accomplished by a well point system which operated continuously for about two months' period at the beginning of the job.

Batching bins and cement storage shed for concrete materials were erected at the site and a road pavement concrete mixer was used with mobile crane, and ¾ cubic yard bucket attached, for mixing and placing concrete. Design of the concrete mix to accommodate the available concrete aggregates was furnished by a commercial testing laboratory after it had made tests of the materials to be used. Winter weather concreting was done, using materials heated to at least 50° F. and not over 120° F., and by covering the newly placed concrete and maintaining its surface temperature at 50° F. or more from 3 to 7 days depending on whether high early strength cement or normal portland cement was used. Oil burning "orchard heaters" were used for maintaining temperatures within the enclosures covering the new concrete.

Metal forms were used extensively for the concrete tank structures and for the concrete of the operating building, excepting that plywood form lining was used for the underside of floor slabs in the operating building. A total of 7,500 cubic yards of reinforced concrete were placed, involving about 480 tons of steel reinforcement.

For most of the work, concrete having a compressive strength of

3,000 lbs. per square inch in 28 days was used but for some of the larger members, such as footings, 2,500 pound concrete was used.

Considerable effort was made to minimize development of cracks in the concrete by use of suitable construction joints, contraction joints and expansion joints. Nevertheless, the finished concrete work was not without some cracks. Fig. 30 shows the several types of joints used.

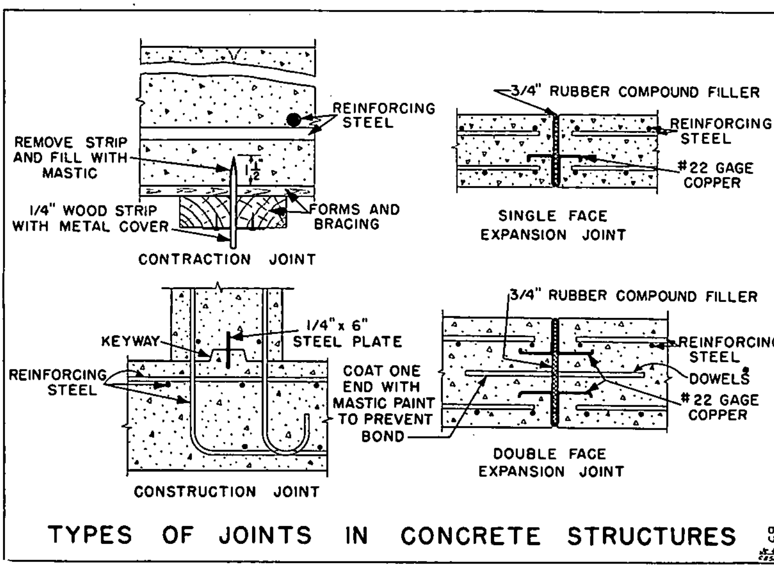


FIG. 30.

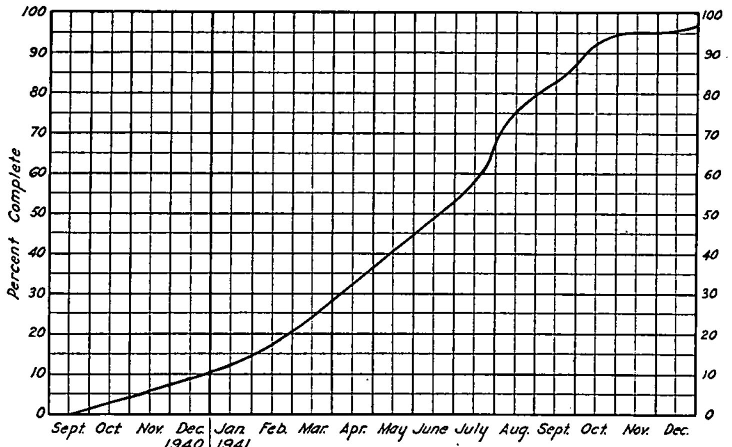
The usual type of construction joint was one with keyway (tongue and groove), and provided with continuous structural steel plate, ¼ inch thick and 6 inches wide.

Contraction joints were used in the exposed concrete surfaces to provide grooves for the development of contraction cracks due to temperature changes. Contraction joints were made by using molded sheet metal attached to the concrete forms to provide grooves about ¼ inch wide and 1½ inches deep. Larger grooves might have been more effective. The metal strips were removed after the concrete had set and the grooves were filled with mastic material. The grooves were placed at locations where it appeared that contraction cracks were most apt to develop.

Two kinds of expansion joints were used: one type consisted of a folded strip of copper, No. 22 U. S. gage, in one face of the concrete member only, and the other type had a folded strip of copper in both faces of the concrete member. A rubber compound filler was used between the two folded faces of the copper strip to accommodate movement at the joints. The copper strip on either side of the joint was firmly embedded in the concrete. One expansion joint was provided across the entire width of the two aeration tanks so that the maximum rigid length of wall and of bottom did not exceed approximately 140 feet.

Brickwork for the superstructure of the operating building consisted of 6 shade, 10 hole, buff bricks laid in lime mortar. The mortar was made with one part portland cement, 1½ parts lime putty and 5 parts sand. All exposed brickwork was backplastered. Nevertheless, some minor cracks in the brickwork have developed and painting with a colorless waterproofing liquid over limited areas has been used, with some success.

Progress and Costs. Construction started the middle of September, 1940, and the bulk of the work was practically finished in about 13 months. Fig. 31 shows the manner in which the work progressed. Some delay was experienced in obtaining and installing mechanical equipment on account of the Federal priority regulations which became effective during the progress of the job.



CRANSTON, RHODE ISLAND
PROGRESS ON CONSTRUCTION
OF SEWAGE TREATMENT WORKS
FIG. 31.

TABLE IX

CRANSTON, RHODE ISLAND
SEWAGE TREATMENT WORKS
COST DATA

Name of Unit	Inside Capacity Dimensions	Inside Capacity Volume Cu. Ft.	Concrete Cu. Yds.	(7) Contractor's Breakdown Price @ $19 per Cu. Yd. for Concrete.	(7) Cost of Concrete in Structure per Cu. Ft. of Capacity Volume	Contractors Breakdown Price for Equipment Total Cost of Equipment	Equipment Cost per Cu. Ft. of Capacity Volume
Grit Removal	18' diameter subsidence chamber, 3' wall height, with influent and effluent channels, cleaning channel. Weir elev. 30.73	1,940	57.1	$1,084.90	$0.56	$4,500	$2.32
Comminution	Octagonal 13'-1" x 11' with 5'-6" wall height. Two 2'-3" diameter siphons.	610	33.7	640.30	1.05	4,100	6.73
Venturi Chamber	23'-8" x 8'-0" with 12' wall height and roof slab.	2,200	60.4	1,147.60	0.52	3,000 (1)	1.36
Grease Removal	20' x 20' with 11.55' wall height. Weir elev. 27.75	5,370	65.1	1,236.90	0.23	2,600	0.48
Primary Settling Tanks	2 tanks 50' x 50' with 10.42' wall height. Sloped bottom. Weir elev. 27.18	55,220	693.2	13,170.80	0.24	10,600	0.19
Aeration Tanks	2 tanks, each with 2 channels 210' x 20' with 13'-10" wall height. Weir elev. 24.70	221,040	2,177.2	41,366.80	0.19	48,000 (2)	0.22
Final Settling Tanks	2 tanks 60' x 60' with 12.17' wall height. Sloped bottom. Weir elev. 23.10	97,560	930.0	17,670.00	0.18	12,250	0.13
Chlorination Channel	121.5' x 6.5' with 8.9' wall height. Crest of Weir at elev. 21.50	7,735	56.2	1,067.80	0.14	3,600 (5)	0.47
Sludge Digestion Tanks	2 tanks 50' diameter with 28' wall height. Hopper bottom, 5'-6" deep.	116,720	642.2	12,201.80	0.10	31,400 (3)	0.27
Sludge Control Building	2 floors 25' x 16', wall height 27'; Superimposed Meter Room 14' x 10'; also waste gas burner enclosure 6' across x 10' high inside.	12,350	188.3	3,577.70	0.29	10,200 (4)	0.83
Sludge Elutriation Tanks	2 tanks 26' x 26' with 11'-7" wall height. Weirs at elev. 29.79 and 28.73 Sloped bottom.	15,780	172.0	3,268.00	0.21	5,970	0.38
Activated Sludge Concentration Tank	26' x 26' with 11'-7" wall height. Sloped bottom. Weir elev. 28.75	7,890	86.0	1,634.00	0.21	2,235	0.28
Digested Sludge Storage Tank	10' x 8' with 7'-9" wall height. Hopper bottom 5' deep and 2' x 4' at base.	810	23.7	450.30	0.56		
Pipe Galleries	Main Pipe Gallery 162'-2" x 20' with wall heights of 17.67', 16.57' and 12.07' Small Pipe Gallery 123' x 6'-6" with wall height of 15.83'	68,315	577.0	10,963.00	0.16		
Operating Building	140'-8" long by about 43'-2" wide	Substructure 102,500 Superstructure 102,100	1,332.7	25,321.30 53,385.00 (6)	0.25 0.52		

(1) Venturi meter only, no pipe included.
(2) Blowers, air filters, silencers, and diffuser system included, no pipe.
(3) Floating covers and heating coils.
(4) Process piping and valves, gas piping and equipment.
(5) Chlorinator.
(6) Structural items including masonry, sash, tile, roofing, and painting.
(7) These costs are exclusive of cost of reinforcing steel, for which add 35%, except in case of Operating Building Superstructure.

The major items of equipment employed by the contractor included:

2 Tractors with drag scrapers, one of 15 cubic yards and one of 7 cubic yards capacity
1 Mobile crane with ¾ cubic yard bucket
1 Roadway Pavement Concrete Mixer
4 5-ton dump trucks
1 3-ton platform truck
Bulldozer blades for the two tractors and the usual miscellaneous pumps, air compressors, and small tools.

A maximum of about 100 were employed during the peak day, of which number many were employees of subcontractors.

The work was done under a lump sum contract of $658,000 and extra work amounted to about $7,200, making the total cost about $665,200. Unit costs applicable to some of the principal items of the work are shown by Table IX.

ACKNOWLEDGMENTS

The designs and engineering supervision of construction have been furnished by Fay, Spofford & Thorndike, of Boston, as Engineer to the Cranston Sewer Commission. The writer has represented the Engineer as partner in charge of the entire project, assisted by Lieutenant-Colonel E. B. Myott, supervising the design of the sewage treatment works; William L. Hyland, supervising the design of pumping stations; and Major L. B. Turner, supervising the design of sewers. During construction, C. W. Riva has served as Resident Engineer, in charge of all field engineering for the entire project, and A. W. Caird has served as Assistant Resident Engineer, in charge of construction at the sewage treatment works.

Construction of the sewage treatment works was done under contract with James A. Munroe & Sons, of North Attleboro, Mass.; all pumping station superstructures were built by Dimeo Construction Company, of Providence, R. I.; and all of the pumping units, electrical controls and other electrical and mechanical appurtenances for the sewage pumping stations were furnished and installed by Yeomans Brothers Co., of Chicago, Illinois.

Acknowledgment is hereby made by the writer, of assistance received from his associates in the firm of Fay, Spofford and Thorndike.

DISCUSSION OF THE PAPER* "SHIELD TUNNELS OF THE CHICAGO SUBWAY"

HOWARD L. KING.† (By letter.) Prof. Karl Terzaghi's article in the July number of the JOURNAL will be of interest to all engineers and of great value to those who follow the engrossing type of construction known as shield tunneling. Some comparisons between the Chicago subway and the vehicle tunnels under the Hudson River may be pertinent.

Hudson River silt is softer than Chicago blue clay, probably softer than any of the clay encountered by the Chicago shields. On the Holland Tunnel (1923-4) the water content was reported at about 32% by weight. No one seems to have made any measurement of the unconfined compressive strength of the silt, either in the case of the Holland Tunnel (1923-4) or the Lincoln Tunnel (1934-5 and 1937-8). Where the Hudson River tubes were driven through silt on the landward side of the bulkhead lines (both in New Jersey and New York) the silt supported itself long enough to permit the use of gravel and grout in the space left by the tail of the shield but under the river, the silt closed down immediately upon the outside of the iron lining as the shield was shoved ahead. In fact, it commonly squeezed into the annular space between the outside of the advanced ring and the inside of the tail of the shield. In places where the silt was particularly soft, this material slowly flowing in over the iron during the shove was a minor hazard; men armed with wood wedges were posted at the top of the iron and at the upper quarter points, to scrape down the silt and thus keep it from falling in sizable chunks on the workers below.

All tunnel segments were provided with grout holes for 1½ inch pipe. Ordinarily there was no reason for disturbing the plugs that closed these holes but if one was taken out the silt flowed into the tunnel in a long sausage. The inflowing silt was under such pressure that it was often difficult to get the cast-iron plug back into the threaded hole. To close these openings a conical wood plug was used,

*By Dr. Karl Terzaghi, presented at a meeting of the Boston Society of Civil Engineers, May 20, 1942, and published in the July, 1942, Journal B.S.C.E.
†Chief Engineer, Mason & Hanger Co., Inc., 24 State St., New York City, N. Y.

the base of the cone being a fairly tight fit inside the threads. This wood plug having stopped the flow of silt, the cast-iron plug could then be screwed into the grout-hole. In other instances (both when the tunnel was under air pressure and when it was not) a plug might be taken out and no silt would enter through the grout hole. An explanation for this difference is suggested by Prof. Terzaghi's remark that if water can drain from the surrounding plastic material through leaking joints in the lining, the clay (or silt) will become consolidated outside the tunnel and hence will stiffen.

Prof. Terzaghi gives the following formula for the force P required to shove a closed shield into a plastic material:

$$P = \frac{1}{0.75}(S + P_1 + P_2 - P_a)$$

It will be of interest to work out this formula for the case of the Lincoln Tunnel shield. The outside diameter was 31′8″; the mean length of the cylindrical shell was 17′. The skin friction of the silt on steel was determined (in caisson sinking) to be about 450 lbs. per sq. ft. This gives S equal to 800 kips.

For the part of the tunnel under the river, one may take the mean silt pressure against the front of the shield as 38 lbs. per sq. in. This makes P_1 amount to 4300 kips. P_2 depends on the non-confined compressive strength which one may take as 600 lbs. per sq. ft. P_2 becomes 1400 kips. Finally P_a, at an air pressure of 16 lbs. per sq. in., equals 1800 kips. Using these values in the equation, P is determined as 6300 kips.

There were 28 ten-inch jacks around the circumference of the shield. Assuming that 26 of them were in working order, it would require a hydraulic pressure of 2900 lbs. per sq. in. to develop the 6300 kips necessary to shove the shield "blind". This figure accords with the remembered facts.

After a shove, when the face of the shield was closed it was necessary to hold the pressure on the jacks to keep the shield from coming back. If the jacks were exhausted, the pressure of the silt would move the shield back against the iron and it would come back more rapidly than it went forward.

In the case of the Chicago shields the amount of muck taken in through the face was regulated so as to produce the minimum disturbance of overlying structures. When the Holland Tunnel shields or the Lincoln Tunnels were under water, the amount of muck taken in was regulated on a totally different basis, namely to keep the back iron from floating.. The story of how this problem was met begins when the north shield from the New Jersey land shaft on the Holland Tunnel first moved out under the waters of the slip on the Jersey side. Experience with the old Hudson & Manhattan shields had indicated that some muck would have to be taken in to prevent the shield and the iron from rising. Muck was taken in, loaded into cars and sent out of the tunnel. The shield and the iron began to rise above the designed grade. The amount of muck taken was increased and later increased again until the full displaced volume was taken in and carted away. But still the back iron rose.

It became evident to the contractor (Booth & Flinn, Ltd.) that he must ballast the tunnel to keep it down. Taking in more muck was not the answer to the problem. A sliding dam was devised to follow the shield; behind the dam, about 25 per cent of the total muck displaced by the shield was deposited. It remained there until tunneling was completed. This scheme, when fully developed and refined, solved the grade problem in the silt on the Holland Tunnel. It was used again on the Lincoln Tunnel with greatly improved technique. Incidentally it is worth noting that the back iron would rise only when the shield was being advanced. It never rose on a Sunday when work was suspended.

The relation between the "heave percentage" and the "percentage opening" in the face of the shield receives some consideration in Prof. Terzaghi's paper. From "The Field Measurement and Study of Stresses in Tunnel Lining", by G. M. Rapp and A. H. Baker, the information was obtained that the percentage opening on the Lincoln Tunnel shield was 0.5%. It is the present writer's opinion that this figure is incorrect. There were two gate openings commonly used and these were 2′6″×2′4″ in the clear. This would give a percentage opening of 1.5%.

The amount of muck taken in during a shove was affected by the following factors; (a) the air pressure in the tunnel; (b) the silt pressure, that is the depth below the water surface; (c) the length of time that the gates were left open. After it had been determined that the taking in of 22 to 28 per cent of the displaced volume created satisfactory working conditions, it was customary to measure the incoming sausage of silt and to close the mud gates when enough had been admitted. Obviously, if the three factors mentioned above were all held constant and the size of the gate opening were reduced, the amount of silt taken in would also have been reduced.

The back iron commonly rose from one to two inches during the first week after it was erected. During this week the shield had advanced about 120 feet. Thereafter it settled, always at least as much as it had risen, and often an inch or an inch and a half more.

CLOSURE

TO THE DISCUSSION OF THE PAPER "SHIELD TUNNELS OF THE CHICAGO SUBWAY"

DR. KARL TERZAGHI, M. BOSTON SOC. C. E. (By letter.) The author is greatly indebted to Mr. H. L. King for his valuable contribution to the subject covered by the paper.

Semi-empirical equations cannot be recommended for general use until their approximate validity has been demonstrated on several occasions. Therefore it was gratifying to learn that the equation for estimating the force P required to shove a shield is in accord not only with the observations in Chicago but also with those on the Lincoln Tunnel.

The prevention of the rise of the Lincoln Tunnel by weighting the bottom of the tunnel with muck deposited behind a movable dam constitutes an interesting analogue to the prevention of the heave of the bottom of the sub-basements adjoining the shield tunnels in Chicago by means of sandbag ballasting as illustrated by Figs. 16 and 17 of the paper.

The tube of the Lincoln Tunnel rose only while the shield was being advanced. The radical deformation of the silt due to shoving transforms the silt temporarily into a liquid. For the same reason the shield receded after shoving over the full length of the shove, if the jacks were exhausted. However, within a few hours after the disturbance the silt becomes again fairly solid whereupon the movements stop. A similar temporary liquefaction occurs when driving piles into soft silt and it causes the piles to rise excessively after each blow. On a pile-driving job in Scotland the piles rose after each blow several inches. In one instance the rise amounted to 15 ft. (1).

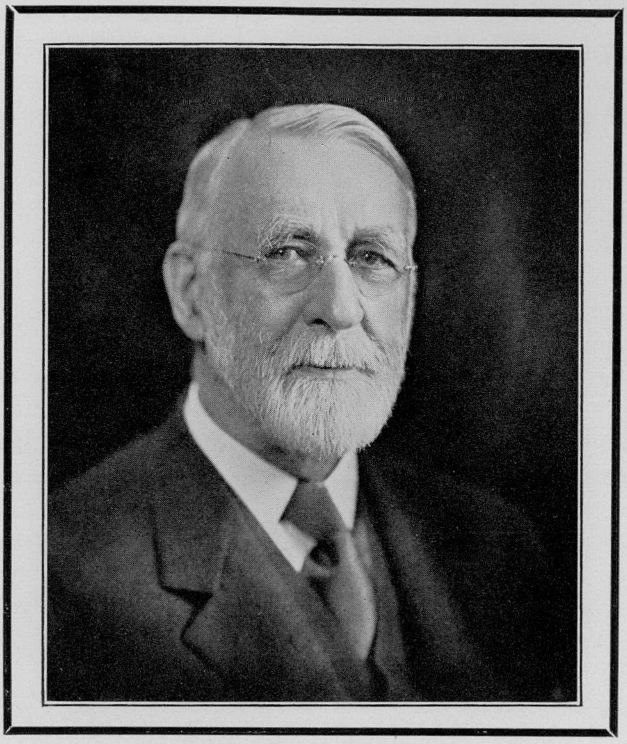
The settlement of the Lincoln Tunnel is a counterpart to the settlement of the Chicago Tunnel. It represents quite obviously a settlement due to remolding of the silt located beneath the tunnel. This, again, is a phenomenon which could be predicted on the basis of our knowledge of the behavior of clays in the laboratory, but no such prediction deserves any confidence until it has been found, by field observations on different jobs, that it is reliable.

The writer notes that the percentage opening in the shield of the Lincoln Tunnel was 1.5 and not 0.5. Therefore the slope of the steep part of the curve C_1 in Fig. 7*a* should be somewhat less steep than shown.

On the basis of the results of the observations in the experimental section, the writer suggested on p. 207 of his paper that the walls of the tubes should be made as thin as compatible with construction requirements. In his opinion, the thickness of the walls of the Chicago tubes (26 in.) could be reduced very considerably without any risk. Since the time when the paper was published, the author learned that 2¾ miles of the shield driven tunnels on a new section of the London Subway have been lined with precast reinforced concrete segments. The segments consist of a 2-in. skin stiffened by longitudinal and circumferential ribs. The total height of the ribs, skin included, is slightly less than 5 in. A brief description of the lining and of the physical properties of the London clay in which the tubes are located is contained in the author's closure of the discussion of the paper on the Liner Plate Tunnels of the Chicago, Ill., subway in the Proc. Am. Soc. C. E. Vol. 69, 1943.

Reference

(1) Terzaghi, K., Discussion of Pile-Driving Formulas, Proc. Am. Soc. C. E., Vol. 68, February 1942, pp. 311-324.



CHARLES T. MAIN
1856-1943

Rich in honors, highly esteemed for his professional accomplishments, and endeared for his calm and philosophic nature and sincerity, Mr. Charles T. Main died at his home, 14 Herrick Street, Winchester, on March 6, 1943.

Mr. Main was an Honorary Member and a Past President of the Boston Society of Civil Engineers. He was one of the country's most distinguished engineers and one of the delegates chosen to assist French Engineers in the rehabilitation of France after the World War.

Mr. Main was born February 16, 1856, in Marblehead, son of Thomas Main, Jr., and Cordelia Green (Reed) Main.

A graduate of Massachusetts Institute of Technology in 1876, he remained there after his graduation as an assistant. After three years in this position he entered the Manchester Mills, Manchester, N. H., as a draftsman. Two years later he went to the Lower Pacific Mills in Lawrence as engineer.

During the 10 years at Lower Pacific Mills, he was instrumental in rebuilding the plant, reorganizing the machinery and installing a new steam and water power plant. He resigned as superintendent of the worsted department in 1891 to devote all his time to engineering.

He married Elizabeth F. Appleton of Somerville, November 14, 1883, and they had three children, Miss Alice Appleton Main of Winchester, Theodore Main of Holyoke, both of whom survive, and the late Charles R. Main, formerly of Winchester. Mrs. Main died May 23, 1936.

He served for three years on the Board of Aldermen and for shorter terms on the school committee and as trustee of the public library while living in Lawrence.

After a year of engineering and textile mill management, he formed an association in 1893 with F. W. Dean, conducting a business largely devoted to textile mill work. This association was dissolved 14 years later and he continued under the name of Charles T. Main. In 1926 the business was incorporated under the name of Charles T. Main Inc., and is still operating under that name, observing the completion of 50 years of engineering this year.

He acted as Consulting Engineer on many projects and as expert witness and referee in many cases. Moving to Winchester in 1893, he served 11 years on the water board, as chairman from 1902 to 1907, and on the Appropriations Committee which is now the Finance Committee.

Through these years he remained in close contact with M. I. T. and was president of the Alumni Association in 1901.

For 10 years he served as Term Member of the Corporation, was made a life member in 1918, and served on the executive committee for 16 years.

During the World War he was consulting engineer for the Construction Division of the U. S. Army and was sent to France as a member of the American Engineering Delegation to assist the French in rehabilitation.

Northeastern University awarded him the honorary degree of Doctor of Engineering in 1935.

He was past president of the American Society of Mechanical Engineers and was awarded its 50-year button. In 1935 he was made a life member of the society and received its medal in 1936. For 11 years he served as president of the Engineers Club of Boston and was later made an honorary member of the club.

A member of the Boston Society of Civil Engineers, he was awarded the Desmond FitzGerald Medal in 1913 and made an honorary member in 1932. He was a member of this Society's Committee on the John R. Freeman Fund since its appointment in 1925, and Chairman since 1932. He was also past president of the American Institute of Consulting Engineers, and a member of the Newcomen Society, a British-American engineering society. He was also awarded a medal by the National Association of Cotton Manufacturers.

He was a member of many engineering and scientific organizations, among which were Society for the Promotion of Engineering Education, American Association for the Advancement of Science, American Academy of Arts and Sciences, and U. S. Institute for Textile Research. His clubs included the Engineers' Club and the University Club.

Rev. Howard J. Chidley of Winchester in paying tribute to Mr. Main expressed the love and esteem in which he was held, in the following words, "Everyone who knew him was impressed by his integrity, and by his quiet spirit; all who knew him intimately had a genuine affection for him; he was simple and modest like all great souls."

OF GENERAL INTEREST

PRIZES AWARDED AT ANNUAL MEETING ON MARCH 17, 1943

The Desmond FitzGerald Medal

TO PROFESSOR JOHN B. WILBUR, MEMBER

Presentation made by President Athole B. Edwards

Mr. Albert E. Kleinert, Chairman of the Committee on Award of the Desmond FitzGerald Award, consisting of Albert E. Kleinert, Donald W. Taylor and Leslie J. Hooper, outlined the purpose of this prize which was instituted and endowed in 1910 by the late Desmond FitzGerald, a past President and Honorary Member of this Society. This medal is awarded annually for a paper presented by a member and published during the year which is adjudged worthy of special commendation for its merit.

The paper selected by this committee and recommended to the Board of Government for the award was that by Professor John B. Wilbur, Member, entitled "The Smith-Putnam Wind Turbine Project", presented at a meeting of the Society held on March 18, 1942, and published in the July, 1942, JOURNAL.

President Edwards on behalf of the Board of Government presented the Desmond FitzGerald medal to Professor Wilbur, who accepted this award with appropriate remarks.

The Hydraulics Section Prize

TO KARL R. KENNISON, MEMBER

Presentation made by President Athole B. Edwards

Prof. Leslie J. Hooper, Chairman of the Hydraulics Section Prize Award Committee, consisting of Francis H. Kingsbury and Professor Thomas R. Camp, and Prof. L. J. Hooper outlined the purpose of the Hydraulics Section Prize which was authorized by the Board of Government in 1924 to be given for a worthy paper given in the Section by a member of the Section.

The paper selected was entitled "Hydraulics of the New Pressure Aqueduct of the Metropolitan Water District," by Karl R. Kennison, Member, presented at a meeting of the Hydraulics Section held on November 18, 1941, and published in the January, 1942, JOURNAL.

The prize consisted of books: "Handbook of Applied Hydraulics," by Calvin Victor Davis; "Sewage Treatment Works," by C. E. Keefer; "American Sewerage Practice," by Leonard Metcalf and Harrison P. Eddy. Mr. Kennison accepted this prize with fitting remarks and expressed his appreciation of the prize.

Clemens Herschel Award

To Karl Terzaghi, Member

Presentation made by President Athole B. Edwards

Prof. Leslie J. Hooper outlined the purpose of the Clemens Herschel Award which was established by a gift from the late Clemens Herschel, a Past President and Honorary Member of the Society, and is awarded for a paper which has been particularly useful and commendable and worthy of recognition. This year the prize was awarded to Dr. Karl Terzaghi, Member, for his paper on "Shield Tunnels of the Chicago Subway", presented at a meeting of the Society held on May 20, 1942, and published in the July, 1942, Journal. The prize, consisted of books: "Report of the Colorado River of the West," by Lieut. Joseph C. Ives; "Adventure by Sea from Art of Old Time," by Basil Lubbock & John Masefield; "French Painting XIXth Century," by S. Rocheblave. Dr. Terzaghi accepted this award with fitting remarks and expressed his appreciation of the award.

PROF. CHARLES M. ALLEN AWARDED FRANKLIN INSTITUTE ELLIOT CRESSON MEDAL

The Franklin Institute, famous throughout the world as a centre of science advancement, and long a medium for the encouragement of scientific progress and inventiveness, awarded its cherished Elliot Cresson medal this year to Professor Charles M. Allen of Worcester Polytechnic Institute for his inspired contribution to the field of hydraulics on April 21, 1943, at the Institute, Philadelphia, Pa.

Much of his career has been devoted to the conduct of efficiency tests of water wheels. In this connection he pioneered the application of the dynamometer which is capable of absorbing large powers at relatively low speeds.

The field tests of water wheels brought out the necessity for improved laboratory facilities for the study of flow phenomena. Probably the most important work of Professor Allen's career was the building of the Alden Hydraulic Laboratory into one of the foremost hydraulic laboratories of the country. In the development of this laboratory he made many contributions to engineering science.

In the field of water measurements, he designed and installed a circular current meter rating station. The outstanding advantages of this design were the vibrationless operation and constant rate of speed. This station has been extensively used for the calibration of current meters, ship logs and pitot tubes.

He has also conducted numerous studies for the design of hydraulic structures. These investigations were made with small scale models in the laboratory.

Outstanding among Professor Allen's achievements, for which particular origination the Cresson award will be made, has been the development of the Salt Velocity Method of measuring the flow of water, which has been used in efficiency tests on large hydraulic turbines in over a hundred power plants in the past twenty years, and has become one of the standard methods of measuring large rates of flow.

BOSTON SOCIETY OF CIVIL ENGINEERS SCHOLARSHIP IN MEMORY OF DESMOND FITZGERALD AWARDED TO STUDENT AT NORTHEASTERN UNIVERSITY

Irving T. Berkland of Norwood, Mass., a senior student, class of 1943, in the Civil Engineering course at the School of Engineering, Northeastern University, was awarded the Boston Society of Civil Engineers Scholarship in memory of Desmond FitzGerald on March 31, 1943, at a convocation of Students held in Jordan Hall. The presentation of the Scholarship of $60 was made by Howard M. Turner, President of the Boston Society of Civil Engineers.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

JANUARY 27, 1943.—A regular meeting of the Boston Society of Civil Engineers was held this evening at the Engineers Club and was called to order by President A. B. Edwards. This was a Joint Meeting with the Sanitary Section B.S.C.E. Seventy-two persons attended the meeting and sixty attended the supper.

President Edwards announced the death of the following members:

Thomas J. FitzGerald who was elected a member December 20, 1922, and who died January 8, 1943.

Barzillai A. Rich, who was elected a member April 18, 1906, and who died January 26, 1943.

President Edwards announced that the February meeting would be a Joint Meeting with the Hydraulics Section, George N. Bailey, Chairman.

President Edwards stated that a form of Amendment to the Constitution to provide for a definite succession to the office of President in the case of a vacancy in that office, signed by 10 members of the Society, was considered by the Board of Government at its meeting December 17, 1942, and that this present meeting had been designated by the Board for a discussion of such an amendment, due notice having been given in the regular meeting notice in ESNE Journal.

The President requested the Secretary to read the proposed amendment to be inserted after paragraph 2 of Article III of the Constitution, as follows:

"In case of a vacancy in the office of President the senior Vice-President or the junior Vice-President shall succeed to the office in the order stated. In case of a failure in the succession, the latest Past-President who is a Member of the Society and willing to serve shall act as President.

"In the case of a vacancy in the office of Secretary or Treasurer, the Board of Government may fill the office for the unexpired term.

"When vacancies occur in other offices or in the Nominating Committee, the Nominating Committee shall, at the time of the Annual Election, make nominations, in cases where otherwise vacancies would remain."

It was moved and seconded that the amendment be adopted.

The President stated that the Board of Government favored this amendment, except that the third paragraph thereof be amended, the wording of which as read by Mr. Stanley M. Dore, of the Board, should be as follows:

"In case of a vacancy in another office, provisions shall be made at the time of the Annual Election so that all offices shall then be filled."

Mr. Dore stated that this form of amendment was acceptable to Prof. C. Frank Allen and the others who signed the petition for the amendment.

VOTED that the revision of the third paragraph as read be accepted.

VOTED that the Amendment as revised be adopted.

The President stated that this matter now will be submitted to the members of the Society for ballot, to be canvassed at the next meeting of the Society on February 17, 1943.

The President then stated that the By-Laws must be amended to be consistent with the Constitution Amendment just adopted, and the Board of Government submits the form of such amendments as follows:

(a) *Delete* from Section 5 (Nominating Committee and Election of Officers) all of paragraph 6, and all of paragraph 8.

(b) Insert at the end of Section 5 a new paragraph,—
"The Nominating Committee shall, at the time of the Annual Election, make nominations to fill vacancies in any office or in the Nominating Committee."

(c) Amend the second sentence of paragraph 2, of Section 5 (Nominating Committee, so as to read as follows:
"It may make nominations whether at the time it consists of nine members or of less, but the approval of at least two-thirds of the members of the Nominating Committee shall be required for a nomination."

(d) Amend second paragraph of Section 6 (Duties of Officers), so as to read as follows:
"The Vice-President in order of seniority shall preside at meetings in the absence of the President."

(e) An additional matter deemed also desirable to modify at this time, relative to election of new members.
To amend the last two sentences of paragraph 3 of Section 7 (Election of Members), so as to read as follows:
"The votes of at least two-thirds of the members of the Board of Government shall be cast to constitute an election, these votes to be cast by letter ballot if necessary. Two or more negative votes shall exclude from election."

VOTED (unanimously) that the proposed amendments to the By-Laws be adopted to be effective if and when the Constitutional Amendment is adopted.

The President announced that final action on these amendments will be taken at the February 17th meeting of the Society.

The President and Prof. Gramstorff each urged members of the Society to attend the legislative hearings to be held on current legislations which affects engineers and architects and particularly in the present form the bill will seriously affect the practise of engineers, referring to House bill No. 1027, entitled, "Architects Registration Law".

The President called upon Prof. Charles O. Baird, Chairman of the Sanitary Section, to carry on any necessary business for that Section.

Prof. Baird then introduced the speaker of the evening, Ralph W. Horne, Partner, Fay, Spofford & Thorndike, who gave an interesting paper on "Cranston Builds Complete Sewerage Works for 53,000 People". The talk was illustrated.

The meeting adjourned at 9:15 P. M.

EVERETT N. HUTCHINS, *Secretary*

FEBRUARY 17, 1943.—A regular meeting of the Boston Society of Civil Engineers was held this evening at the Engineers Club and was called to order by the President, Athole B. Edwards. This was a Joint Meeting with the Hydraulics Section, BSCE. Forty-four members and guests attended this meeting and thirty-eight persons attended the dinner.

The President announced the deaths of the following members:

Walter B. Foster, who was elected a member September 18, 1901, and who died November 28, 1942.

William H. G. Mann, who was elected a member September 21, 1910, and who died August 30, 1942.

Thomas H. Sexton, who was elected a member January 25, 1933, and who died February 2, 1943.

Samuel P. Waldron, who was elected a member March 19, 1913, and who died February 6, 1943.

The report of the Tellers, Frank L. Flood and Lawrence M. Gentleman, on the ballot vote on the Amendment to Constitution, action on which was taken at the Society Meeting January 27, 1943, was presented by Mr. Gentleman who stated that there were 274 ballots cast and that all were in favor of the Amendment. The President declared that the Amendment has therefore been adopted as follows:

"In case of a vacancy in the office of President the senior Vice-President or the junior Vice-President shall succeed to the office in the order stated. In case of a failure in the succession, the latest Past-President who is a Member of the Society and willing to serve shall act as President.

"In the case of a vacancy in the office of Secretary or Treasurer, the Board of Government may fill the office for the unexpired term.

"In case of a vacancy in another office, provisions shall be made at the time of the Annual Election so that all offices shall then be filled."

The President stated that at the last meeting of the Society January 27, 1943, amendments to the By-Laws also had been acted upon favorably and that at this meeting the final action is to be taken. The President referred to the announcement made in ESNE Journal of the changes in By-Laws which are to be adopted, and therefore the reading of them was omitted.

On motion duly made and seconded it was *VOTED* that the amendments to the By-Laws acted upon favorably at the January 27, 1943, meeting of the Society be adopted.

The changes made are as follows:

(a) *Delete* from Section 5 (Nominating Committee and Election of Officers) all of paragraph 6, and all of paragraph 8.

(b) Insert at the end of Section 5 a new paragraph,—
"The Nominating Committee shall, at the time of the Annual Election, make nominations to fill vacancies in any office or in the Nominating Committee."

(c) Amend the second sentence of paragraph 2, of Section 5 (Nominating Committee), so as to read as follows:

"It may make nominations whether at the time it consists of nine members or of less, but the approval of at least two-thirds of the members of the Nominating Committee shall be required for a nomination."

(d) Amend second paragraph of Section 6 (Duties of Officers), so as to read as follows:
"The Vice-Presidents in order of seniority shall preside at meetings in the absence of the President."

(e) An additional matter deemed also desirable to modify at this time, relative to election of new members.
To amend the last two sentences of paragraph 3 of Section 7 (Election of Members), so as to read as follows:
"The votes of at least two-thirds of the members of the Board of Government shall be cast to constitute an election, these votes to be cast by letter ballot if necessary. Two or more negative votes shall exclude from election."

The President stated that this is a Joint Meeting with the Hydraulics Section, BSCE, and consequently called upon Mr. George N. Bailey, Chairman of that Section, to conduct any necessary business to be completed at this time.

Mr. Bailey then introduced the speaker of the evening, Mr. S. S. Smith, Manager, Products Pipe Line Department, Shell Oil Company, New York, who gave a very interesting talk on "Mechanical Features of Products Pipe Line Operation." The talk was illustrated.

The speaker was given a rising vote of thanks.

Meeting adjourned at 9:15 P. M.

EVERETT N. HUTCHINS, *Secretary*

MARCH 17, 1943.—The ninety-fifth annual meeting of the Boston Society of Civil Engineers was held today at the Boston City Club, Auditorium, and was called to order at 4:30 P. M., by the President, Athole B. Edwards.

President Edwards announced the death of the following members:

Past President and Honorary Member, Charles T. Main, who was elected a member June 17, 1891, and who died March 6, 1943.

Will J. Sando, who was elected a member October 20, 1897 and who died February 23, 1943.

Royal Luther, who was elected a member March 15, 1916, and who died February 18, 1943.

The minutes of all previous meetings of the current fiscal year which have been printed in the various issues of the JOURNAL were approved as printed.

The Secretary reported the election of the following members on this date:

Grade of Student: S. E. Allen, J. J. Antognini, J. J. Bulba, F. M. Childs, R. J. Chouinard, H. W. Cohen, J. I. Connelly, R. F. Dutting, O. Epstein, G. B. Fay, R. G. Fine, S. L. Fletcher, G. W. Laakso, Jr., L. B. Loitherstein, L. J. Majahad, P. X. Navin, K. E. Palmer, W. R. Prescott, F. Sattin, R. W. Sommers, J. R. Sullivan, C. E. Sullivan, Jr., G. H. Wilton, Jr., R. B. Wellington.

The Annual Reports of the Board of Government, Treasurer, Secretary and Auditors were presented. Reports were also made by the following committees: Membership, Social Activities, Relations of Sections to Main Society, Welfare, Library, and John R. Freeman Fund.

VOTED that the reports be accepted with thanks and placed on file, and that they be printed in the April, 1943, JOURNAL.

VOTED that the incoming Board of Government be authorized to appoint such Committees as it deems desirable.

The report of the Tellers of Election, Frank L. Flood and Lawrence M. Gentleman, was presented and in accordance therewith the President declared the following had been elected officers for the ensuing year:

President—Howard M. Turner
Vice-President (for one year)—S. Stanley Kent
Vice-President (for two years)—Samuel M. Ellsworth
Secretary (for one year)—Everett N. Hutchins
Treasurer (for one year)—Chester J. Ginder
Directors (for two years)—Emil A. Gramstorff, John B. Wilbur
Nominating Committee (for two years)—George N. Bailey, Walter M. Fife, Frank L. Lincoln.

The retiring President, Athole B. Edwards, then gave his address on "A Civil Engineer's Comments on Planning". Fifty-five members attended this part of the meeting.

The meeting adjourned to assemble at 7:30 P. M., the Annual Dinner being held during the interim.

The President then called the meeting to order for the presentation of prizes.

The President requested Mr. Albert E. Kleinert, Chairman of the Committee on the Award of the Desmond FitzGerald Medal to outline the purpose of this prize and to present the candidate for this prize. The President, on behalf of the Society, then made the presentation of the Desmond FitzGerald Medal to Prof. John B. Wilbur, member, for his paper on "The Smith-Putnam Wind Turbine Project", presented at a meeting of the Society held on March 18, 1942, and published in the July, 1942, JOURNAL.

The President requested Prof. Leslie J. Hooper, Chairman of the Committee on the Hydraulics Section Prize, to define the purpose of that prize and to present the candidate. The President, on behalf of the Society, then made the presentation of the Hydraulics Section Prize, consisting of books, to Karl R. Kennison, member, for his paper on "Hydraulics of the New Pressure Aqueduct of the Metropolitan Water District", presented at a meeting of the Hydraulics Section held on November 18, 1941, and published in the January, 1942, JOURNAL. The books were:

"Handbook of Applied Hydraulics," by Calvin Victor Davis.
"Sewage Treatment Works," by C. E. Keefer.
"American Sewerage Practice," by Leonard Metcalf and Harrison P. Eddy.

The President requested Prof. Hooper to define the purpose of the Clemens Herschel Award and to present the candidate for this Award. President Edwards then, on behalf of the Society, presented this Award to Dr. Karl Terzaghi, member, for his paper, "Shield Tunnels of the Chicago Subway", presented at a meeting of the Society held on May 20, 1942, and published in the July, 1942, JOURNAL. The prize consisted of books as follows:

"Report on the Colorado River of the West," by Lt. Joseph C. Ives.
"Adventure by Sea from Art of Old Time," by Basil Lubbock & John Masefield.
"French Painting XIXth Century," by S. Rocheblave.

President Edwards then introduced the guest speaker of the evening, Dean William C. White, College of Engineering, Northeastern University, who gave an especially interesting talk on "Engineering Education—Yesterday, Today and Tomorrow".

At the conclusion of the address President Edwards introduced the newly elected President, Howard M. Turner, who then assumed the chair and adjourned the meeting at 8:30 P. M.

One hundred forty-one members and guests attended the dinner.

EVERETT N. HUTCHINS, *Secretary*

APRIL 21, 1943.—A Joint Meeting of the Boston Society of Civil Engineers with the Northeastern Section, American Society of Civil Engineers was held this evening at the Engineers Club. Eighty-four members and guests attended the meeting and dinner.

President O. G. Julian presiding at the Joint Meeting called upon President Howard M. Turner of the Boston Society of Civil Engineers to conduct any BSCE matters of business.

President Turner expressed his appreciation of the fact that the arrangements for this program were carried out by the ASCE.

He called upon the Secretary to announce the election of members to Boston Society of Civil Engineers at the Board of Government Meeting held on April 13, 1943. Those elected were as follows:

Grade of Member: Alexander W. Caird, Clifford N. Cann, Liangsheng Chen, William F. Condon, 3rd, Herbert A. Kammer, Wilbur C. Nylander, Leslie M. Stewart.

Grade of Junior: Robert P. Burden, Henry E. Weiss.

Grade of Student: Herbert A. Hayward, Jr.

President Turner announced that at the May 21 meeting Prof. Thomas R. Camp and Mr. P. Charles Stein will present a discussion of "Velocity Gradients and Internal Work on Fluid Motion".

President Julian then resumed the chair and called upon Prof. Gramstorff, Secretary, for announcements. Also he introduced Major E. J. Brehaut of the U. S. Army Office Procurement Division who briefly presented the needs of the Army for highway and construction men who have requisite practical experience and college training.

President Julian then introduced the speaker of the evening, Col. Charles R. Gow, who gave a most interesting address on "Looking Backward over 50 Years of Engineering Experience". The address outlined the breadth of experience and emphasized the personality factors on all relationships of engineers and others and was interspersed with the characteristic humor of the speaker.

Adjourned at 9:15 P. M.

EVERETT N. HUTCHINS, *Secretary*

SANITARY SECTION

MARCH 3, 1943.—The Annual Meeting of the Sanitary Section was held in the lecture hall of the new building at Northeastern University on March 3, 1943. Before the meeting about twenty-five members and guests dined at the "Lobster Claw" restaurant on Huntington Avenue. Chairman Baird called the meeting to order at 7:25 P. M.

The report of the nominating committee was read by Chairman Ellsworth. The report was accepted, and following the usual motion, the clerk was instructed to cast one ballot for the nominees as read. The officers elected for the year 1934-44 were as follows:

Chairman—William L. Hyland
Vice-Chairman—Edwin B. Cobb
Clerk—Kenneth F. Knowlton
Executive Committee — Frederick Gibbs, Allen J. Burdoin, Prof. Charles Baird.

Chairman Baird introduced the speaker of the evening, Mr. F. Wellington Gilcreas of the New York State Department of Health, whose talk was entitled "The Function of Sanitation in the

Control of Food Dispensing Establishments."

Mr. Gilcreas traced the history of the New York law regarding the sanitation of food dispensing establishments and outlined the methods by which the standards adopted were determined. He discussed the brief evidence available concerning the spread of disease by poor dish washing and described the methods of field inspection. Following the talk several slides and a twenty-minute reel of sound moving pictures were shown illustrating the New York practice. A lively discussion followed the pictures.

The meeting adjourned at 9:30 P. M. There were sixty members and guests present at the meeting.

EDWIN B. COBB, *Clerk*

DESIGNERS' SECTION

DECEMBER 16, 1942.—The December meeting of the Designers Section was a joint meeting with the main Sociey. It was held Wednesday, December 19, 1942, at the Engineers Club, preceded by a dinner at 6:00 P. M.

President Edwards presided at the opening of the meeting, but turned it over directly to Prof. E. A. Gramstorff, Chairman of the Designers Section, under whose auspices the meeting had been arranged. The general subject for the evening was "Conservation of Critical Construction Materials." This was presented by four speakers on four separate phases of the main subject as follows: Miles N. Clair—"Concrete"; Dean Peabody, Jr.,—"Reinforced Concrete Construction"; Albert G. Dietz—"Timber"; and Walter C. Voss—"Structural Steel".

An interesting and instructive question period followed in which all of the four speakers were called on for further remarks. At the close of the question period the meeting adjourned.

L. M. GENTLEMAN, *Clerk*

JANUARY 13, 1943.—The January meeting of the Designers Section of the Boston Society of Civil Engineers was held in the Society's rooms Wednesday evening, January 13, 1943, preceded by dinner at the Ambassador Restaurant.

The meeting was called to order by the chairman at 6:50 P. M. The clerk's reports for both the November meeting of the Section and the joint meeting of the section with the main Society in December were read and accepted. It was then voted that the three most recent past chairmen of the Section be the nominating committee for the following year. The members of this committee are, therefore, John B. Wilbur, Kimball R. Garland and J. D. Mitsch.

An interesting and instructive talk was given by Herman G. Dresser, a past chairman of this Section, on the subject: "Structural Problems of the Sanitary Engineer." A question period followed the talk and adjournment was at 8:35 P. M. The attendance was 36.

L. M. GENTLEMAN, *Clerk*

FEBRUARY 10, 1943.—The February meeting of the Designers Section of the Boston Society of Civil Engineers was held in the Society's rooms Wednesday evening, February 10, 1943, preceded by a dinner at the Ambassador Restaurant.

The meeting was opened by the Chairman at 6:50. The clerk's report of the January meeting was read and accepted. The report of the nominating committee was also read but no action was required on this report at this meeting. The scheduled speaker for this evening was Mr. Frank H. Malley and his proposed subject was "Recent Developments in Boston's Thoroughfare Plan," but, due to illness, Mr. Malley was unable to be present. In the absence of the speaker a general discussion was held. Announcement was made of the Air Raid Shelter Conference to be held at Northeastern University, February 27, 1943.

The Chairman announced the program for the March meeting and the meeting was then adjourned at 9:00 P. M. Attendance 20.

L. M. GENTLEMAN, *Clerk*

MARCH 10, 1943.—The Annual Meeting of the Designers Section was held in the Society Rooms this evening at 6:45 P. M. with Chairman Emil A. Gramstorff presiding. The report of the previous meeting was read and approved. The report of the Executive Committee, covering the activities of the Section for the past year, was read and approved.

The report of the Nominating Committee was read and accepted, and the following officers were elected for the ensuing year:

Chairman—Herman G. Protze
Vice-Chairman—Lawrence M. Gentleman
Clerk—Eugene Mirabelli
Executive Committee—Thomas C. Coleman, William F. Covil, Dean Peabody, Jr.

The talk for the evening was on "The Structural Use of Plastics" given by Mr. T. S. Caswell, Director of Research, Plastics Division, Monsanto Chemical Co., Springfield, Mass. There was an audience of 80 persons.

The meeting adjourned at 8:30 P. M.

EUGENE MIRABELLI, *Clerk*

APRIL 7, 1943.—A regular monthly meeting of the Designers Section was held in the Society Rooms this evening at 6:45 P. M. with Chairman Herman G. Protze presiding. The minutes of the previous meeting were read and approved.

The speaker for the evening was Rev. Daniel Linehan, S.J., of the Seismological Observatory, Weston College, who gave an illustrated talk on "Applications of Seismology to Engineering."

There was an audience of 42 persons. The meeting adjourned at 8:45 P. M.

EUGENE MIRABELLI, *Clerk*

NORTHEASTERN UNIVERSITY SECTION

JANUARY 8, 1943.—At 7:20 P. M. a meeting of Northeastern University Section was called to order in Room 228N by Irving T. Berkland, President. The Secretary's report was read and accepted.

President Berkland announced that the Section had acquired copies of the Boston Society of Civil Engineers JOURNALS covering the period 1939-1942 inclusive, through the efforts of Mr. Everett N. Hutchins, Secretary, and that the journals are now available to members at the Section Library. President Berkland then read a letter from Mr. A. F. Davis, Secretary of the James F. Lincoln Arc Welding Foundation regarding the Foundation's new $6,750 Annual Engineering Undergraduate Award and Scholarship Program. The object of the program is—"to encourage engineering students to study arc welded construction so that their imagination, ability and vision may be given opportunity to extend knowledge of this method and thus aid the war effort and the economic reconstruction in the peace which is to follow". The awards will be made for papers describing the conversion from other methods to arc welded construction of parts of machines, complete machines, trusses, girders or structural parts. Interested members may obtain additional information regarding the awards from Professor Baird of the Civil Engineering Department. Coming meetings of the Society were then announced.

Mr. Howard M. Turner, Consulting Engineer and Lecturer on Water Power Engineering, Graduate School of Engineering, Harvard University, was then introduced to President Berkland. Mr. Turner's subject was "Water Storage".

The Speaker reviewed the various purposes for which water is stored, namely for: (1) Domestic and Fire Protection Supply Regulation, (2) Irrigation, (3) Navigation, (4) Power Development, (5) Flood Control.

The safe yield of a reservoir or basin supplied by a single drainage area was defined as: the amount of water that hydraulic authorities can count on at all times. Due to seasonal and annual variations of stream flow the low-water stream flow is increased through the use of reservoirs. Increasing the stream flow also increases the sanitation of the stream by diluting the pollution and assures ample water supplies for domestic purposes.

Mr. Turner discussed several hydro-electric power developments as examples of water storage for power purposes and how such stored water is utilized. The speaker pointed out that water is stored in arid or semi-arid regions for irrigation purposes to permit the growing of crops. Also, where water transportation is necessary water is stored to increase the depth of the channel of the stream and thus make it more navigable. For flood control purposes reservoirs are utilized to collect the overflow water of streams during periods of high-water levels and supply water during low-water periods.

Mr. Turner then mentioned Boulder Dam which has created the largest single, artificial water storage basin in the world, with an estimated capacity of 1,350 billion gallons. Enough water to cover the State of Massachusetts to a depth of three feet. The water stored behind this dam is utilized as follows: 31% for flood control, 48% for low-water regulation of domestic water supplies and 21% for irrigation and power purposes.

The talk was supplemented by many diagrammatic and pictorial slides which were very effective in correlating and giving a more complete understanding of the subject matter. A question period followed the address.

The meeting was attended by thirty-one guests, 4 faculty members and twenty-nine members of N.U.C.E.S., a a total of sixty-four.

The meeting was adjourned at 8:50 P. M.

RICHARD W. NEWCOMB, *Clerk Pro-tem*

FEBRUARY 12, 1943.—The meeting was called to order by Edward L. Burke, Vice-President, at 7.30 P. M. This was a Joint Meeting of Northeastern University Section with American Society of Mechanical Engineers and American Institute of Chemical Engineers.

The speaker of the evening, T. Alfred Fleming, of the National Board of Fire Underwriters, who spoke on "Fire Prevention and Protection As Applied to War Plants".

Mr. Fleming began his talk by stating that fire prevention is a problem for all engineers, not just the Civil, Electrical, Chemical, Mechanical Engineer, but each one of them has his own share in the problems that arise. He continued by saying that the first duty of an engineer is a complete and unbiased analysis of the problem before him. The second duty that an engineer must face is that his knowledge is never complete, but must always be ready to acept new ideas and facts.

War plants are losing a tremendous amount of money each day from fire.

Mr. Fleming pointed out that the three main causes of this great loss is from inflammable vapors, re-utilized electrical power machines and static electricity. The planning and designing of war plants is really the most important place for fire prevention principles to be applied. He stressed the necessity for eliminating careless and dangerous practices.

A long question period followed the

address, and every person present realized that the opportunity that they had in hearing Mr. Fleming was truly beyond their expectations.

The meeting was well attended by 28 members of the N.U.C.E.S. and 37 guests. The meeting adjourned at 9.45 P. M.

HERBERT S. CHURCH, *Secretary*

MARCH 12, 1943.—The meeting was called to order by Irving T. Berkland, President at 7.15 in Room 228, New Building, Northeastern University. The results of the election of officers for the coming year were given by Richard Burbank, Chairman of the Ballot Committee. The results are as follows:

Joseph C. Lawler—President
John Wiita—Vice-President
Richard Newcomb—Secretary
Chatson Wong—Treasurer

Division A—Herbert Standke, Senior Representative; Henry Bishop, Junior Representative; Kenneth Palmer, Middler Representative.

Division B—Edward Lobacz, Senior Representative; Charles Pistorino, Junior Representative; Richard Dutting, Middler Representative.

President Berkland next introduced the speaker of the evening, Mr. Lansing S. Heberd, Senior Civil Engineer for the Massachusetts Department of Public Works.

Mr. Heberd spoke on "Highway Construction" using as an example the Northern Circumferential, new route 128, that will run from the Worcester Turnpike at Wellesley to Beverly. This new road will serve as a belt line when constructed. The original planning started about eight years ago and is now being held up from construction by the war.

Mr. Heberd presented an outline of the tremendous amount of work required in the planning, design and location of a highway before the actual construction can begin. Many surveys and reconnaissance trips are required before the final location is decided upon. The design of the highway is affected by the traffic that the road will carry.

Mr. Heberd explained the entire procedure interestingly and thoroughly, supplementing his talk with maps, plans and aerial photographs. The talk was followed by a long question period.

The meeting was attended by thirty-four student members of the Society.

Preceding the meeting, a dinner was held at the Lobster Claw with twenty-five present.

HERBERT S. CHURCH, *Secretary*

APPLICATIONS FOR MEMBERSHIP

[April 20, 1943]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

WILLIAM S. CROCKER, Hingham, Mass. (b. July 22, 1880, Brookline, Mass.) Graduated from Harvard College in 1904, received A.B. Degree. Experience, 1904, rodman, New York, New Haven & Hartford, Railroad; 1905, transitman, Aspinwall & Lincoln; 1905-1908, Levelman, Transitman, Panama Canal, Isthmus of Panama; 1909-1916, Division Engineer, Resident Engineer, Cape Cod Canal; 1917, Town Engineer, Walpole, Mass.; 1918, Supervisor of Construction, New York, New Haven and Hartford Railroad; 1918-1929, assistant engineer, partner, Aspinwall & Lincoln. 1930 to date in private practice as Civil Engineer, plans, reports, specifications and supervision of contracts for roads, sewers, water systems, wharves, dredging. Many boundary, topographical and hydrographic surveys. Registered Professional Engineer and Registered Land Surveyor, State of Massachusetts. Refers to *L. A. Chase, R. K. Hale, C. B. Humphrey, M. Linenthal, W. J. Sullivan.*

EDOUARD N. DUBE, Reading, Mass. (b. October 14, 1899, Cleveland, Ohio.) Graduated from Massachusetts Institute of Technology in 1921, S.B. degree in Civil Engineering. Experience, 1921-1922, with the Boston & Albany Railroad as chairman. Work consisted of usual railroad surveying and plans. For the next three months employed as Chief of Party by firm of Cobb, Beeseley and Miles of Springfield, Mass., on reconnaissance and location survey for a forty mile transmission line. September, 1922, to August, 1927, served as Maintenance Engineer with the Holyoke and Northampton (Mass.) Street Rys. After six months' training with the former, was placed in charge of all maintenance of track and structures with other affiliated companies. Work included also, track reconstruction, surveying and supervision of several crews of men; August, 1927 to January, 1933, was employed by the Palmer Steel Company of Springfield, Mass., steel fabricators. Work consisted of detailing and checking, with some design and estimating. In addition, was given nearly all the field work such as surveys for new buildings, additions to old structures, engineering supervision on erecting and much new construction at our own plant. The latter included construction of two large craneways, railroad sidings, street relocation, water line and drainage system. While unemployed, I drew up plans and specifications for a new dam for the West Springfield Water Department; June, 1933, to October, 1941, worked with the National Park Service, for the first two years as Superintendent of CCC Camp and for the rest of the time as Inspector and administrator of the camps in Vermont, New Hampshire and Maine. This work involved construction of roads, bridges, dams, buildings, and water and sanitary systems. Had charge of the design office which planned the work and acted as Procurement Officer for Vermont Camps. October, 1941, to May, 1942, with General Electric Company of Lynn, as Design-draftsman. This work was mainly structural design and details on very large buildings for their new work. May, 1942, to present date with Haller Engineering Associates Inc., of Cambridge, Mass., as Design Engineer. Refers to *J. B. Babcock, M. F. Brown, C. H. Holmberg, T. Worcester, C. R. Gow, S. T. Drew.*

ARTHUR K. HAUSER, Everett, Mass. (b. February 4, 1910, Revere, Mass.) General Course including Mathematics at Revere High School. One year under the direction of a private tutor, subjects Mathematics and Drafting, 1934-1935. Experience, 1937-1940 with Department of Public Works, Engineering Division, drafting record plans of state highways; May, 1941—August, 1941, computer-draftsman in employ of Howard M. Turner, Consulting Engineer, Boston; August, 1941—October, 1942, engineering draftsman in employ of Fay, Spofford & Thorndike, Boston; October, 1942—January, 1943, mechanical draftsman in employ of Massachusetts Institute of Technology, Cambridge, Mass: January, 1943 to date, draftsman at Fay, Spofford & Thorndike, Boston. Refers to *F. M. Cahaly, W. L. Hyland, M. H. Mellish, H. M. Turner.*

MARIANO J. LORENTE, Boston, Mass. (b. January 8, 1883, Spain.) Degree of Civil Engineer from University of Glasgow, Scotland, Class of 1906. Worked with various engineering firms in Glasgow, Scotland. Since coming to this country, in November, 1910, until July, 1923, have worked with the following firms: General Electric Company, as Structural Engineer; Trussed Concrete Steel Company, as Structural Designer; Lockwood, Greene and Company, as Structural Designer; Stone and Webster, as Structural Designer; Harry M. Hope Engineering Company, as Structural Designer; Jackson and Moreland, as Structural Designer; Mowll and Rand, as Structural Engineer. Since July, 1923, until August, 1941, was the structural engineer for Kendall, Taylor and Company, with three intervals, during which I was Structural Engineer for Cram and Ferguson. From August, 1941, until the present, have been Structural Engineer for Chas. T. Main, Inc. Have contributed to all the Civil Engineering Magazines in this country. Lectured in September, 1915, before the Boston Society of Civil Engineers. Am also an Affidavit Engineer in the Building Department of the City of Boston. Became a United States Citizen, November, 1916. Refers to *A. W. Benoit, F. M. Gunby, P. S. Rice, L. G. Ropes, W. F. Uhl.*

ROBERT E. MARTIN, Cambridge, Mass. (b. April 16, 1908, Louisville, Kentucky.) Received B.S. degree in Civil Engineering from University of Louisville in 1931. Professional Civil Engineer from University of Louisville in 1941. Attended University of South Carolina, 1930-1931. Attended Harvard Summer School, 1942. Experience, on graduating from the University of Louisville employed by the Southern Bell Telephone and Telegraph Company for the purpose of designing wiring plans. May, 1932, to January, 1933, employed by the City of Louisville Engineering Department, in charge of Sewer Design. January, 1933, to January, 1938, with Jefferson County Road Department, duties included road design, location and construction. January, 1938, to January, 1939, employed as Resident Engineer with the Kentucky Department of Highways. January, 1939, to December, 1941, employed as Resident Engineer with J. S. Watkins, Consulting Engineer of Lexington, Kentucky, was in responsible charge of design and construction of the Middlesboro, Kentucky, Sanitary Sewer System. Later designed the water distribution systems for the Lexington Signal Corps Depot and Camp Campbell in Kentucky. December, 1941, to March, 1942, employed by Havens and Emerson, Consulting Engineers at Fort Knox, Kentucky, duties included design of sewers and water distribution systems. March, 1942, to date with Stone and Webster Engineering Corporation, as Industrial Engineer. Refers to *G. G. Bogren, R. N. Mayall, L. N. Reeve, G. R. Strandberg.*

CHARLES A. MCMANUS, Quincy, Mass. (b. March 19, 1887, Boston, Mass.) Attended Boston Public Schools, and regular four year course in Civil Engineering at Massachusetts Institute of Technology. Experience, with New York Board of Water Supply, construction of the Catskill Aqueduct; with assignments in the Hudson River Division of the Northern Aqueduct, consisting of giving line and grade on the Hudson River Tunnel crossing, the alignment of the grade tunnel through Breackneck Mountain, and a section of cut and cover aqueduct. With the Directors of the Port of Boston for two years on construction of the Commonwealth and Fish Piers. In private practice in Boston, for a period of three years, engaged in surveys for land development, laying out buildings and investigations for settlement of buildings for drainage suits. During the War was government inspector (Civilian) with the U. S. Navy on steel construction. After the War employed by Stone & Webster Corporation in the steel designing department; also with the Sturtevant Mill Company in Dorchester on the design of mill buildings and fertilizer plants. From 1921 to date with the Massachusetts Department of Public Works, on the construction of roads and bridges. Refers to *J. B. Babcock, T. C. Coleman, E. F. Copell, H. V. Macksey, E. N. Hutchins.*

FERDINAND A. TRAUTNER, Wellesley Hills, Mass. (b. February 24, 1909, Fitchburg, Mass.) Graduate of Fitchburg High School. In 1926 entered Worcester Polytechnic Institute, at Worcester, Mass. From June, 1929—October, 1930, worked for the Westinghouse Electric and Manufacturing Company as a junior engineering student in various test departments and laboratories. Returned to Worcester Technology and received B.S. degree in Electrical Engineering in June, 1932. Experience, December, 1933, engineer with Massachusetts Traffic Survey. In January 1936, with Rhode Island Concrete Pipe Company, the following year the corporation made me a director and officer. Duties with this corporation included administration and engineering relative to our business both as to production and sales. In June, 1942, became Chief Engineer for the New England Concrete Pipe Corporation of which the Rhode Island Concrete Pipe Corporation is a wholly owned subsidiary. Duties at present in this capacity include the above mentioned duties for the Rhode Island Concrete Pipe Company. Though my degree was granted in Electrical Engineering that particular branch of engineering with which the bulk of my work is concerned is Civil Engineering. Both corporations manufacture plain and reinforced concrete sewer and drain pipe for use in the construction of drains, culverts, storm and sanitary sewers. Refers to *M. N. Clair, H. G. Protze, G. S. Rutherford.*

ADDITIONS

Members

CLIFFORD N. CANN, 3 Arlington Street, Cambridge, Mass.

LIANG-SHENG CHEN, 117 Trowbridge Street, Cambridge, Mass.

WILLIAM F. CONDON, JR., 11 Laurel Street, Watertown, Mass.

WILLIAM F. CONDON, 3rd., 21 Longfellow Road, Watertown, Mass.

PERE O. HAAK, Black Hotel, Oklahoma City, Oklahoma.

HERBERT A. KAMMER, 269 East Argyle St. Valley Stream, Long Island, N. Y.

JULIUS LASKER, 346 Walnut Avenue, Roxbury, Mass.

JAMES E. LEVINGS, University of Maryland, College Park, Maryland.

JOHN A. MCAULIFF, 100 Carver Road, Newton Highlands, Mass.

CHESTER A. MINEHAN, 120 Hemenway Street, Boston, Mass.

CARL H. SEILS, 195 Bellevue Road, Quincy, Mass.

LESLIE M. STEWART, 38 Memorial Drive, Cambridge, Mass.

Juniors

HENRY E. WEISS, 694 Washington Street, Boston, Mass.

ROBERT P. BURDEN, 18 Day Street, Somerville, Mass.

Student Members

STUART E. ALLEN, 222 Hemenway Street, Boston, Mass.

JOHN J. ANTOGNONI, 12 Elsinore Street, Concord, Mass.

JOSEPH J. BULBA, 368 Franklin Avenue, Hartford, Conn.

FREDERICK M. CHILDS, Box 35, Marstons Mills, Massachusetts.

RICHARD J. CHOUINARD, 20 Hancock Street, Revere, Mass.

HERBERT W. COHEN, 42 Nevada Street, Winthrop, Mass.

JAMES I. CONNELLY, 118 Pembroke Street, Boston, Mass.

RICHARD F. DUTTING, 12 Wildwood Street, Winchester, Mass.

OSCAR EPSTEIN, 18 No. Russell Street, Boston, Mass.

GEORGE B. FAY, 78 Westland Avenue, Boston, Mass.

ROBERT G. FINE, 168 Bryand Street, Malden, Mass.

STANLEY L. FLETCHER, 256 Kenduskeag Avenue, Bangor, Maine.

HERBERT A. HAYWARD, JR., 206 Fairmont Ave., Hyde Park, Mass.

GEORGE W. LAAKSO, JR., 5 Winthrop Street, Peabody, Mass.

LEONARD B. LOITHERSTEIN, 64 Goodale Road, Mattapan, Mass.

LEO J. MAJAHAD, High Street, North Carver, Mass.

PHILIP X. NAVIN, 124 East Elm Avenue, Wollaston, Mass.

KENNETH E. PALMER, 15½ Hodges Street, Attleboro, Mass.

WILLIAM R. PRESCOTT, 278 Lake Avenue, Newton Highlands, Mass.

FRANCIS SATTIN, 43 Franklin Avenue, Revere, Mass.

RODERIC W. SOMMERS, 38 Franklin Street, Medford, Mass.

JOHN R. SULLIVAN, 342 E. Main Street, Three Rivers, Mass.

CLIFFORD E. SULLIVAN, JR., 257 Geneva Avenue, Dorchester, Mass.

GEORGE H. WILTON, JR., Main Street, Gleasondale, Mass.

RICHARD B. WELLINGTON, 24 Francis Street, Brookline, Mass.

LEON P. PIATELLI, 56 Rockdale Street, Mattapan, Mass.

DEATHS

LEWIS D. THORPE, Dec. 4, 1942
THOMAS J. FITZGERALD, Jan. 8, 1943
BARZILLAI A. RICH, Jan. 26, 1943
THOMAS H. SEXTON, Feb. 2, 1943
SAMUEL P. WALDRON, Feb. 6, 1943
WM. M. G. MANN, Aug. 30, 1942
WALTER B. FOSTER, Nov. 28, 1943
CHARLES T. MAIN, Mar. 6, 1943
ROYAL LUTHER, Feb. 18, 1943
WILL J. SANDO, Feb. 23, 1943

ANNUAL REPORTS

REPORT OF THE BOARD OF GOVERNMENT FOR YEAR 1942-1943

Boston, Mass., March 17, 1943

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the By-Laws, the Board of Government presents its report for the year ending March 17, 1943.

Membership

Twenty new members, 1 junior, and 42 students have been added during the year, and 5 members, 1 junior have been reinstated, making a total addition of 69 members.

During the year 16 members have died, 6 have resigned, 1 member has had dues remitted and resignation accepted, 14 members have been dropped for non-payment of dues; 1 junior for failure to transfer; 48 students for failure to transfer, and 20 students who are no longer in college, making a total deduction of 106.

The present net membership of the Society consists of 6 honorary members, 603 members, 33 juniors, 63 students, 7 associates, making a total membership of 712, a net loss for the year of 37.

The honorary membership list is as follows:

Dr. Karl T. Compton, elected February 17, 1932
Prof. C. Frank Allen, elected March 16, 1932
Joseph R. Worcester, elected February 21, 1934
Charles M. Allen, elected January 14, 1942
Arthur W. Dean, elected January 14, 1942
Charles R. Gow, elected January 14, 1942

Deaths

Members:

Edward G. Gushee, December 4, 1941
Daniel L. Turner, March 12, 1942
Franklin A. Snow, March 19, 1942
William F. Cummings, April 10, 1942
Leonard E. Schlemn, April 29, 1942
William M. G. Mann, August 20, 1942
Charles R. Main, August 22, 1942
Walter B. Foster, November 28, 1942
Lewis D. Thorpe, December 4, 1942
Thomas J. FitzGerald, January 8, 1943
Barzalli A. Rich, January 26, 1943
Thomas H. Sexton, February 2, 1943
Samuel P. Waldron, February 6, 1943
Charles T. Main, March 6, 1943
Royal Luther, February 18, 1943
Will J. Sando, February 23, 1943

Remission of Dues and Extension of Time

The Board of Government granted a number of members an extension of time for payment of dues and has remitted the dues of other members. With much regret the Board voted this year to drop from membership those who had not paid their 1942 dues, for which an extension had been granted. The Board remitted dues and accepted a resignation from one member. In the case of 25 members, dues for the year ending March 17, 1943, have been remitted, including 22 in the armed services and a member a prisoner in the Philippines.

The Board has granted 13 members an extension of time for payment of dues for year ending March 17, 1943.

Exemption of Dues

Eighty-six members are now exempt from dues in accordance with By-Laws 8, which provides that "a member of any grade who has paid dues for forty years, or who has reached the age of seventy years and has paid dues for thirty years, shall be exempt from further dues".

Meetings of the Society

Eight regular meetings, since the Annual, have been held during the year.

The October meeting was the Annual Student Night, attended by Student Chapters, American Society of Civil Engineers, at Harvard University, Massachusetts Institute of Technology, Tufts, Rhode Island State College, New Hampshire State University, Brown University, Worcester Polytechnic Institute, Connecticut University and the Northeastern University Section of the Boston Society of Civil Engineers.

The total attendance at all meetings was 800 persons; the largest attendance was 200 and the smallest 50. Suppers have been a feature at all the meetings and they were well attended, a total of 743 persons for the year.

The papers and addresses given were as follows:

March 18, 1942. Annual Meeting. Address of retiring President, Albert Haertlein, "Effects of Blast on Buildings", followed by dinner and entertainment.

April 15, 1942. Joint Meeting, American Society of Civil Engineers, Northeastern Section, and Boston Society of Civil Engineers. "The Technical Aspects of Air Raid Protection," by Dr. Harold E. Wessman, Professor of Civil Engineering, New York University.

May 20, 1942. "Shield Tunnels of the Chicago Subway," by Dr. Karl Terzaghi, Lecturer on Soil Mechanics and Engineering Geology, at Harvard University.

September 23, 1942. Joint Meeting. Boston Society of Civil Engineers and Boston Post, Society of American Military Engineers. "Smoke Screens for Protection of Vital Industries and Public Utilities and Their Relation to the Conservation of Fuel," by Lt. Col. J. W. H. Myrick, President of Boston Post, Society of American Military Engineers and Director of Smoke Abatement Division, Massachusetts Department of Public Utilities.

October 21, 1942. Student Night. Joint Meeting. Boston Society of Civil Engineers and American Society of Civil Engineers, Northeastern Section and Student Chapters ASCE and Northeastern University Section BSCE. "War Construction," by Theodore Reed Kendall, Editor of *Contractors and Engineers Monthly.*

November 17, 1942. "Between the Tropics of Cancer and Capricorn", by

Professor Gordon M. Fair, Gordon McKay, Professor of Sanitary Engineering, Harvard University.

December 16, 1942. Joint Meeting. Boston Society of Civil Engineers and Designers Section, BSCE. A Symposium—"Concrete", by Miles N. Clair; "Reinforced Concrete Construction", by Dean Peabody; "Timber", by Albert G. Dietz; "Structural Steel", by Walter C. Voss.

January 27, 1943. Joint Meeting. Boston Society of Civil Engineers and Sanitary Section BSCE. "Cranston Builds Complete Sewerage Works for 53,000 People", by Ralph W. Horne, Partner, Fay, Spofford & Thorndike, Boston, Mass.

February 17, 1943. Joint Meeting. Boston Society of Civil Engineers and Hydraulics Section BSCE. "Mechanical Features of Products Pipe Line Operation", by Mr. S. S. Smith, Manager, Products Pipe Line Department, Shell Oil Company, New York.

Sections

Twenty-six meetings were held by the Sections of the Society during the year. These meetings of the Sections, offering opportunity for less formal discussion, have continued to demonstrate their value to their members and to the Society. The variety of subjects presented has made an appeal to the members, as indicated by the general attendance at these meetings.

Sanitary Section Meetings. The Sanitary Section has held 6 meetings during the year, with an average attendance of 46. The papers and meetings are listed in the report of the Executive Committee.

Designers Section Meetings. The Designers Section has held 8 meetings during the year, with an average attendance of 44. The papers and meetings during the year are listed in the report of the Executive Committee.

Highway Section Meetings. The Highway Section has held no meetings during the year.

Hydraulics Section Meetings. The Hydraulics Section has held 3 meetings during the year, with an average attendance of 35. The papers and meetings are listed in the report of the Executive Committee.

Northeastern University Section Meetings. The Northeastern University Section held 9 meetings and excursions during the year, with an average attendance of 63. The present membership includes 63 now in attendance in the University. The meetings held are listed in the report of the Executive Committee.

Journal

The report of the Editor of the JOURNAL for the calendar year 1942 will be printed in the April, 1943, JOURNAL.

*Funds of the Society**

Permanent Fund. The Permanent Fund of the Society has a present value of about $62,000. The Board of Government authorized the use of as much as necessary of the current income of this fund in payment of current expenses.

John R. Freeman Fund. In 1925 the late John R. Freeman, a Past President and Honorary member of the Society, made a gift to the Society of securities which was established as the John R. Freeman Fund, the income from which is about $1000. The income from this fund is to be particularly devoted to the encouragement of young engineers. Mr. Freeman suggested several uses, such as the payment of expenses for experiments and compilations to be reported before

*Details regarding the values and income of these funds are given in the Treasurer's report.

the Society; for underwriting meritorious books or publications pertaining to hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to this Society; or establishing a traveling scholarship every third year open to members of the Society for visiting engineering works, reports of which would be presented to the Society. No additional scholarship was authorized during the year, but the John R. Freeman Fund Committee authorized the expenditure of an amount ($650) sufficient to cover the cost of printing the Report of the Boston Society of Civil Engineers Committee on Floods, Section 2 of the January, 1942, JOURNAL.

Edmund K. Turner Fund. In 1916 the Society received 1,105 books from the library of the late Edmund K. Turner, and a bequest of $1000, "The income of which is to be used for library purposes." The Board voted to use $35 of the income for the purchase of books for the library.

Alexis H. French Fund. The Alexis H. French Fund, a bequest amounting to $1000, was received in 1931 from the late Alexis H. French of Brookline, a former Past President of the Society. The income of this fund is "to be devoted to the library of the Society". The Board voted to use $35 of the available income for the purchase of books for the library.

Desmond FitzGerald Fund. The Desmond FitzGerald Fund, established as a bequest from the late Desmond FitzGerald, a Past President and Honorary member of the Society, provided that the income from this fund shall "be used for charitable and educational purposes". The Board voted on April 15, 1942, to appropriate from the income of this fund the sum of $60, to be known as the Boston Society of Civil Engineers Scholarship in memory of Desmond FitzGerald, and to be given to a student of Northeastern University. Presentation of this Scholarship was made by Vice-President Athole B. Edwards at a student mass meeting at the University on April 22, 1942, to Richard D. Sutliff, of Gloversville, New York, a senior student in Civil Engineering.

Tinkham Memorial Fund. The "Samuel E. Tinkham Fund", established in 1921, at the Massachusetts Institute of Technology by the Society "to assist some worthy student of high standing to continue his studies in Civil Engineering", had a value of $2,422.71 on June 30, 1942. Henry Martyne Paynter, Jr., of McLean, Virginia, a sophomore student in Civil Engineering, has been awarded this scholarship for the year 1942-1943.

Clemens Herschel Fund. This fund was established in 1931, by a bequest from the late Clemens Herschel, a former Past President and honorary member of the Society. The income from this fund is to be used for the presentation of prizes for particularly useful and commendable papers presented at meetings of the Society. The present value of this fund is about $1,000. The expenditure made during the year from this fund was for prizes.

Edward W. Howe Fund. This fund, a bequest of $1,000, was received December 2, 1933, from the late Edward W. Howe, a former Past President of the Society. No restrictions were placed upon the use of this money, but the recommendation of the Board of Government is that the fund be kept intact, and that the income be used for the benefit of the Society or its members. No expenditure from this fund was made during the year.

Prizes

Desmond FitzGerald Medal. The Desmond FitzGerald Medal (bronze) was provided for in 1910 as an endowed prize by the late Desmond FitzGerald, a former Past President and honorary member of the Society. The prize is awarded annually to a member who presents an original paper to the Society which is published in the JOURNAL for the current year.

In accordance with the recommendation of the Committee on Awards, the Board of Government voted to award a Desmond FitzGerald Medal to Prof. John B. Wilbur, member, for his paper, "The Smith-Putnam Wind Turbine Project", presented at a meeting of the Society held on March 18, 1942, and published in the July, 1942, issue of the JOURNAL.

Section Prizes

The Board of Government voted on April 12, 1924, to present a prize for a worthy paper given in each section by a member of that section. "This award to consist of books suitably inscribed."

Hydraulics Section Prize. The Board adopted the recommendation of the Hydraulics Section Prize Award Committee and voted that the Hydraulics Section Prize be awarded to Karl R. Kennison, member, for his paper on "Hydraulics of the New Pressure Aqueduct of the Metropolitan Water District", presented at a meeting of the Hydraulics Section held on November 18, 1941, and published in the January, 1942, JOURNAL. The prize consisted of the following books:

"Handbook of Applied Hydraulics", by Calvin Victor Davis.
"Sewage Treatment Works", by C. E. Keefer.
"American Sewerage Practice", by Leonard Metcalf and Harrison P. Eddy.

Clemens Herschel Award

The late Clemens Herschel, a former Past President and Honorary Member, made a bequest to the Society which would provide for the presentation of prizes for papers presented at meetings of the Society which have been particularly useful and worthy of grateful acknowledgment. On recommendation of the Committee on Awards, the Board voted to award the Clemens Herschel prize to Dr. Karl Terzaghi, member, for his paper on "Shield Tunnels of the Chicago Subway", presented at a meeting of the Society held on May 20, 1942, and published in the July, 1942, JOURNAL. The prize consisted of the following books:

"Report on the Colorado River of the West", by Lieut. Joseph C. Ives.
"Adventure by Sea from Art of Old Time", by Basil Lubbock & John Masefield.
"French Painting XIXth Century", by S. Rocheblave.

Amendments to Constitution and By-Laws

The Society voted to adopt an amendment to the Constitution to provide for a definite succession to the office of President in the case of a vacancy in that office, action on which was taken at the January 27 and February 17, 1943, meetings of the Society, and also several amendments to the By-Laws to make them consistent with the amendment to the Constitution.

Social Activities

Six of the regular meetings were held at the Engineer's Club; one held at the Boston City Club and one held at University Commons Hall, Northeastern University, preceded by suppers, under direction of the Social Activities Committee. As usual the most enthusiastic meeting was Student Night held in October, and attended by members of the Student Engineering Societies of Massachusetts Institute of Technology, Harvard University, Tufts, Rhode Island State College, New Hampshire State University, Brown University, Worcester Polytechnic Institute, Connecticut University and Northeastern University Section of the Boston Society of Civil Engineers.

Library

The report of the Committee on Library contains a complete account of the library activities during the past year.

Society Activities

The usual special committees dealing with the general activities and conduct of the Society have included the following: Program, Publication, Membership, Library, Social Activities, Relations of Sections to Main Society. Other special committees have included the following: Subsoils of Boston, Desmond FitzGerald and other prizes, the Welfare Committee, Investments, the John R. Freeman Fund. Each of these Committees has made a distinct contribution to the Society and has developed fields of endeavor which will prove a great benefit to the members.

The Society has co-operated with the Engineering Societies of New England, and members of the Society have served on Engineering Societies' Committees.

Your Board, in conclusion, wishes to express its appreciation of the excellent work done by the officers of the Sections and by the Committees of the Society.

ATHOLE B. EDWARDS, *President.*

REPORT OF THE TREASURER

Boston, Mass., March 17, 1943

To the Boston Society of Civil Engineers:

The financial standing of the Society on March 6, 1943, at the close of the fiscal year, is shown in the following:

Table 1. Distribution of Funds—Receipts and Expenditures.
Table 2. Record of Investments.

The receipts from dues this year amounted to $4,653, which is $240 less than the average amount which has been received from this source during the past five years. Some of this difference can be accounted for by the fact that the dues of members serving in the Armed Forces are remitted on the request of such members.

The income to the Current Fund has been insufficient to meet expenditures for current expenses and a transfer of $1,410.74 from the income of the permanent to the Current Fund has been necessary to meet this deficit.

This transfer amounts to 62% of the income from the permanent fund as compared with a similar transfer amounting to 12% for the last fiscal year. This large increase comes as a direct result of war conditions, since the cost of many of the items affecting current expenses has risen considerably, while the income from investments has fallen slightly below the previous year level.

The amounts transferred from the Permanent Fund during the last five years are shown in the following table:

	1938-39	1939-40	1940-41	1941-42	1942-43
Total Expenditures from Current Fund					$8243
Misc. receipts to Current Fund except dues					2180
Expenditures less misc. Receipts.	$5860	$5860	$5345	$5878	$6063
Receipts from dues	4874	4853	4961	4876	4653
Transfers from income of Permanent Fund	$986	$1007	$384	$1002	$1410

The holdings of the Society in Cooperative Bank Shares has been reduced during the year from $19,490.68 on March 6, 1942, to $12,392.68 on March 6, 1943. Running shares to the amount of $978.10 were sold to provide cash for current expense and the proceeds from matured shares to the amount of $7000 were reinvested in United States Savings Bonds, Series G, in accordance with the vote of the Board of Government.

No sales of stocks or bonds of the Society were made during the year and the only change made in these holdings was the purchase of the $7000 in United States Savings Bonds, Series G, as mentioned above. The total book value of all securities and cash now stands at $97,061.73, an increase of $1,627.45 during the year.

The following table shows the comparative book values of the two principal funds at the close of each year and the ratio of market to book values. It should be kept in mind that the value of the Freeman Fund is largely dependent upon expenditures made from the fund during the year. The growth of the Permanent Fund is affected not only by the percentage of return on investments but also by the amount it has been necessary to transfer from the income of this fund to meet current expenses.

	Mar. 10, 1939	Mar. 10, 1940	Mar. 10, 1941	Mar. 6, 1942	Mar. 6, 1943
Permanent Fund	$56,672	$58,138	$60,527	$61,080	$62,283
John R. Freeman Fund	26,949	26,522	27,666	26,528	26,862
Market Value in per cent of Book Value	92.75%	92.28%	87.92%	83.44%	88.57%

The following table will show for the past five years the book values of securities and bank deposits and the total value of all holdings not including the value of the library and physical property.

	Mar. 10, 1939	Mar. 10, 1940	Mar. 10, 1941	Mar. 6, 1942	Mar. 6, 1943
Bonds	$32,279.96	$32,527.96	$30,782.49	$31,610.49	$38,670.49
Cooperative Banks	15,041.52	16,512.94	17,971.92	19,490.68	12,392.68
Stocks	41,747.17	41,747.17	44,957.17	43,967.17	43,967.17
Cash	2,454.98	1,767.45	2,428.01	365.94	2,031.39
	$91,523.63	$92,552.52	$96,139.59	$95,434.28	$97,061.73

The market values of securities rose with respect to the book values during the year but the return on many of the stocks declined, presumably because of the tax burden due to war conditions.

In addition to the Treasurer's cash balance of $2,031,39, the Secretary has a "change fund" of $30.00 which should be included to show total assets.

Respectfully submitted,

CHESTER J. GINDER, *Treasurer*

TABLE 1—DISTRIBUTION OF FUNDS—RECEIPTS AND EXPENDITURES

	Book Value March 6, 1942	Interest and Dividends	Net Profit (or loss) at Sale or Maturity	Transfer of Funds Purchased	Transfer of Funds Sold	Book Value March 6, 1943
Bonds	$31,610.49	$1,140.50	....	$7,060.00		$38,670.49
Cooperative Banks	19,490.68	451.35	....	4,901.35	$11,999.35	12,392.68
Stocks	43,967.17	1,909.12	....			43,967.17
				Net Increase		
Cash available for Investment	—1,134.06			1,665.45		531.39
Totals (except Current Fund)	$93,934.28	$3,500.97	....	$13,626.80	$11,999.35	$95,561.73
	Book Value March 6, 1942	Allocation of the Above at 3.727%		Misc. Receipts	Misc. Expenditures	Book Value March 6, 1943
Permanent Fund	$61,080.11	$2,276.48		$ 338.00	$ 1,410.74	$62,283.85
John R. Freeman Fund	26,528.01	988.71			654.68	26,862.04
Edmund K. Turner Fund	975.97	36.37			28.10	984.24
Desmond FitzGerald Fund	1,933.93	72.08			63.70	1,942.31
Alexis H. French Fund	1,032.27	38.47			35.00	1,035.74
Clemens Herschel Fund	1,211.86	45.17			19.30	1,237.73
Edward W. Howe Fund	1,172.13	43.69				1,215.82
	$93,934.28	$3,500.97		$ 338.00	$ 2,211.52*	$95,561.73
Current Fund	1,500.00			8,243.99*	8,243.99	1,500.00
Totals	$95,434.28	$3,500.97		$8,581.99*	$10,455.51*	$97,061.73

*Includes transfer of $1,410.74 from income of the Permanent Fund to the Current Fund.

TABLE 2—RECORD OF INVESTMENTS

	Date of Maturity or Classification	Fixed or Current Interest Rate	During the Year March 6, 1942 to March 6, 1943: Interest Received	Additional Amount Invested	*Sold or Matured* Amount Received	Profit + (or Loss —)	March 6, 1943: Par Value	Book Value	Market Value
BONDS									
American Telephone & Telegraph Co.	Sept. 1, 1956	3 %	$ 18.00	....	....	..	$ 600.00	$ 603.00	$ 663.00
Baltimore & Ohio RR Co.	Aug. 1, 1944	4 %	80.00	....	....	..	2,000.00	2,013.75	1,580.00
Canadian Pacific RR	July 2, 1949	4 %	152.50	....	....	..	5,000.00	5,342.50	4,406.25
Eastern Mass. Street Ry. Co.	Jan. 1, 1948	4½%	45.00	....	....	..	1,000.00	1,022.50	1,045.00
Penn. Central Light & Power Co.	Nov. 1, 1977	4½%	45.00	....	....	..	1,000.00	1,052.89	1,046.25
The Pennsylvania Railroad Co.	June 1, 1965	4½%	45.00	....	....	..	1,000.00	1,017.74	1,060.00
The Pennsylvania Railroad Co.	Apr. 1, 1970	4½%	45.00	....	....	..	1,000.00	971.58	957.50
Puget Sound Power & Light Co.	June 1, 1949	5½%	55.00	....	....	..	1,000.00	1,025.00	1,021.25
Standard Oil Co. of N. J.	July 1, 1953	2¾%	27.50	....	....	..	1,000.00	1,021.25	1,050.00
Texas Electric Service Co.	July 1, 1960	5 %	100.00	....	....	..	2,000.00	2,000.00	2,167.50
The Toledo Edison Co.	July 1, 1968	3½%	70.00	....	....	..	2,000.00	2,092.50	2,172.50
Union Pacific RR Co.	June 1, 1980	3½%	70.00	....	....	..	2,000.00	2,125.00	2,145.00
United States Savings Bonds, Series D	Jan. 1, 1950	.....	60.00	$ 60.00	....	..	3,000.00	2,400.00	2,400.00
United States Savings Bonds, Series G	June 1, 1953	2½%	200.00	....	....	..	8,000.00	8,000.00	7,752.00
United States Savings Bonds, Series G	July 1, 1954	2½%	87.50	7,000.00	....	..	7,000.00	7,000.00	6,916.00
Western Maryland RR Co.	Oct. 1, 1952	4 %	40.00	....	....	..	1,000.00	982.78	925.00
Totals			$1,140.50	$7,060.00			$38,600.00	$38,670.49	$37,307.25

TABLE 2—RECORD OF INVESTMENTS—*Continued.*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 6, 1942 to March 6, 1943				March 6, 1943		
			Dividends Received	Additional Amount Invested	*Sold or Matured* Amount Received	*Sold or Matured* Profit + (or Loss —)	Number of Shares	Book Value	Market Value
CO-OPERATIVE BANKS									
Codman Co-operative Bank	Series 37	3½%	$ 34.40	$ 54.40	$4,000.60	....		....	....
Codman Co-operative	Matured Shares	3 %	45.00	2,000.00	....	....	10	$2,000.00	$2,000.00
Bank	Paid up Shares	3 %	45.00	2,000.00	....	....	10	$2,000.00	$2,000.00
Merchants Cooperative Bank	Series 145	3 %	126.15	311.15	7,998.75	....		....	....
Suffolk Co-operative Federal Savings & Loan Assoc.	Series 134	3 %	175.80	535.80	....	....	30	7,392.68	7,392.68
Suffolk Co-operative Federal Savings & Loan Assoc.	Matured Shares	2½%	25.00	....	....	....	5	1,000.00	1,000.00
Totals			$451.35	$4,901.35	$11,999.35			$12,392.68	$12,392.68

TABLE 2—RECORD OF INVESTMENTS—*Continued.*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 6, 1942 to March 6, 1943: Dividends Received	Additional Amount Invested	Sold or Matured: Amount Received	Sold or Matured: Profit + (or Loss —)	March 6, 1943: Number of Shares	Book Value	Market Value
STOCKS									
American Tel. & Tel. Co.	Common	$9.00	$414.00	....	....	..	46	$5,346.04	$6,560.75
Bankers Trust Co., N. Y.	Common	1.40	42.00	....	....	..	30	1,590.00	1,421.25
Central Hanover Bank & Trust Co. of N. Y.	Common	4.00	120.00	....	....	..	30	3,210.00	2,707.50
Commonwealth & Southern Corp.	Cum. Pfd.	.75	6.00	....	....	..	8		
Commonwealth & Southern Corp.	Common	....	....	....	....	..	25	1,019.89	360.97
Commonwealth & Southern Corp.	Opt. Warrants	....	....	....	....	..	12		
Consolidated Edison (Gas) Co. of N. Y.	Common	1.60	32.00	....	....	..	20	1,906.50	380.00
General Electric Co. of N. Y.	Common	1.40	70.00	....	....	..	50	2,341.47	1,787.50
Hartford Fire Insurance Co.	Common	2.50	25.00	....	....	..	10	761.25	946.25
The Home Insurance Co., N. Y.	Common	1.65	49.60	....	....	..	31	1,245.00	914.50
Minnesota Power & Light Co., Minn.	Pref.	7.00	70.00	....	....	..	10	980.00	820.00
National Dairy Products Corp.	Common	.80	40.00	....	....	..	50	1,154.74	837.50
National Fire Insurance Co. of Hartford	Common	2.00	40.00	....	....	..	20	1,240.00	1,200.00
New England Power Assoc.	Pref.	4.00	80.00	....	....	..	20	1,815.00	755.00
New York Central R.R.	Common	1.00	10.00	....	....	..	10	870.45	143.75
North American Trust Shares	Jul. 15, 1955	12.2¢	183.00	....	....	..	1500	5,342.00	3,795.00

TABLE 2—RECORD OF INVESTMENTS—*Continued.*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	Dividends Received	During the Year March 6, 1942 to March 6, 1943			March 6, 1943		
				Additional Amount Invested	*Sold or Matured* Amount Received	*Sold or Matured* Profit + (or Loss —)	Number of Shares	Book Value	Market Value
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	1.50	90.00	....	....	..	60	1,922.02	1,770.00
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	1.37	27.52	....	....	..	20		637.40
Pacific Gas & Elec. Co.	Common	2.00	128.00	....	....	..	64	1,808.79	1,712.00
Southern California Edison Co.	Cum. Orig. Pfd.	1.75	70.00	....	....	..	40	1,161.22	1,624.80
Southern California Edison Co., Ltd.	Common	1.50	9.00	....	....	..	6	539.75	465.00
Southern California Edison Co.	Common	1.50	21.00	....	....	..	14		
Standard Oil Co. of N. J.	Common	2.00	20.00	....	....	..	10	479.54	508.70
Tampa Electric Co.	Common	1.65	49.50	....	....	..	30	1,151.25	607.50
Timken Roller Bearing Co.	Common	2.00	22.50	....	....	..	15	1,018.97	690.00
Trimount Dredging Co.	Pref.	....	....	....	....	..	2	....	....
U. S. Smelting, Refining & Mining Co.	Pref.	3.50	70.00	....	....	..	20	1,365.04	1,375.00
United States Steel Corp.	Common	4.00	40.00	....	....	..	10	860.75	545.00
United States Trust Co. of Boston	Conv. Pref.	.80	180.00	....	....	..	225	4,837.50	3,318.75
Totals			$1,909.12					$43,967.17	$35,884.12

REPORT OF THE SECRETARY

Boston, March 6, 1943

To the Boston Society of Civil Engineers:

The following is a statement of cash received by the Secretary, and of the expenditures approved by the President, in accordance with the Budget adopted by the Board of Government.

FOR THE YEAR ENDING MARCH 17, 1943

CURRENT FUND ACCOUNT

	Account Number	Expenditures	Receipts
Office			
Secretary, salary and expense	(1)	$ 240.00	
Stationery, printing and postage	(2)	281.54	
Incidentals and Petty Cash	(3)	162.15	
Insurance and Treasurer's Bond	(4)	83.55	
Safety Deposit Box	(5)	12.00	
Quarters, rent, light, telephone	(7)	1,753.63	$600.00
Office—clerical	(8)	1,434.20	
Auditors for 1942 accounts and Investment services	(9)	340.00	
Meetings			
Rent of halls	(11)	212.54	
Stationery, printing	(12)	35.95	
Social Activities	(13)	364.45	143.70
Stereopticon and Reporting	(14, 15)	2.00	
Annual Meeting (March, 1942)	(16)	90.00	
Sections			
Sanitary Section	(21)	4.00	
Designers Section	(22)	34.00	
Highway Section	(23)	0.00	
Northeastern University Section	(24)	12.50	
Hydraulics Section	(25)	7.00	
Journal			
Editor, salary and expense	(31)	308.00	
Printing and Postage	(32)	1,899.70	
Reprints	(33)	112.20	
Advertising	(34)		771.00
Sales of JOURNALS and reprints	(35)		604.76
Library			
Librarian, salary and expense	(41)	52.86	
Periodicals	(43)	88.58	5.50
Binding	(44)	32.30	
Fines on overdue books	(45)		5.14
Bank Charges	(53)	7.81	
Dues to Eng'g. Societies of N. E.	(59)	622.19	
Dues from BSCE Members	(70)		4,653.00
Badges for Members	(51)	37.44	37.44

	Account Number	Expenditures	Receipts
Binding JOURNALS for Members	(52)	13.40	12.71
Transfer Income Permanent Fund to Current Fund			1,410.74
Total Current Fund to be accounted for		$8,243.99	$8,243.99
Entrance Fees to Permanent Fund			$338.00

20 new members; 1 junior; 42 students; 5 juniors transferred to members; 3 students transferred to juniors; but 2 new members and 1 junior transferred to members were exempt from payment of entrance fee and transfer fee.

The above receipts have been paid to the Treasurer, whose receipt the Secretary holds. The Secretary holds cash amounting to $30 included as payment under Item 3 (Petty Cash) to be used as a fixed fund or cash on hand for making change at buffet suppers.

Respectfully submitted,
EVERETT N. HUTCHINS, *Secretary.*

REPORT OF THE AUDITING COMMITTEE

Boston, March 17, 1943

We have reviewed the records and accounts of the Secretary and Treasurer of the Boston Society of Civil Engineers and the report of William J. Hyde, Certified Public Accountant, who has examined said records and accounts and we have examined the securities enumerated by the Treasurer.

We have accepted and present herewith with our approval the signed report of the Auditors.

C. FREDERICK JOY, JR.
HERMAN G. DRESSER
Auditing Committee of the Directors of the Boston Society of Civil Engineers.

Boston, Mass., March 17, 1943

C. FREDERICK JOY, JR.
Chairman of the Auditing Committee
Boston Society of Civil Engineers
Boston, Mass.
DEAR SIR:

In accordance with instructions, I have completed the annual audit of the financial records of the Society for the fiscal year ended March 6, 1943, and report below.

Securities held by the Society as at March 6, 1943, were examined and found in order. All coupons for interest dues were collected. Dividends earned were correctly accounted for.

Receipts reported to have been received by the Secretary were in agreement with his records and were found to be correctly entered in the Treasurer's accounts.

Cooperative Bank earnings were verified and found correct. Accounts paid up within the year were reinvested in Matured Shares and Government Bonds, and any cash remainder was deposited.

All disbursements were in settlement of vouchers duly approved by the President and Secretary and were substantiated by examination of checks paid by the bank.

Following past custom, the Secretary's "Change Fund", $30.00, is not included in the Treasurer's funds.

A verified copy of your Treasurer's Report is attached hereto and summarizes the detailed accounts shown in his ledger.

The records have been audited in detail, are correct and were found in excellent condition.

Respectfully submitted,
WILLIAM J. HYDE, *Certified Public Accountant*

REPORT OF THE EDITOR

Boston, Mass., January 25, 1943

To the Board of Government
Boston Society of Civil Engineers:

The JOURNAL for the calendar year 1942 (Volume XXIX), was issued quarterly, in the months of January, April, July and October, as authorized by the Board of Government on December 20, 1935.

During the year 1942 there have been published twelve papers presented at meetings of the Society and Sections, one other technical article and reports of the BSCE Committee on Floods, and the Sanitary Section Committee on Minimum Velocities for Sewers. The Table of Contents and Index for the year are included in the October, 1942, issue.

The John R. Freeman Fund Committee authorized an expenditure to cover the cost of printing the report of the BSCE Committee on Floods. Extra copies of this report are in stock as well as reprints of the Report of the Sanitary Section Committee's report on Sewers.

The four issues of the JOURNAL contained 550 pages of papers and discussions, 7 pages of Index, and 41 pages of advertising, a total of 598 pages. An average of 1,125 copies per issue were printed. The net cost was $1,017.32 as compared with $1,294.73 for the preceding year.

The cost of printing the JOURNAL was as follows:

Expenditures		
Composition and printing	$2,364.51	
Cuts	642.65	
Wrapping, mailing and postage	99.32	
Editing	300.00	
Copyright	8.00	
Total Expenditures		$3,414.48
Receipts		
Contribution from John R. Freeman Fund	$ 654.68	
Receipts from sales of JOURNALS and Reprints	707.48	

Receipts from Advertising	1,035.00
Total Receipts	$2,397.16
Net cost of JOURNAL to be paid from Current Fund	$1,017.32

Respectfully submitted,

EVERETT N. HUTCHINS, *Editor*

REPORT OF THE COMMITTEE ON MEMBERSHIP

Boston, March 10, 1943

To the Boston Society of Civil Engineers:

During the past year letters of invitation to join the society were sent to a number of men suggested by members of the committee. As some of the members of the committee were transferred away from this locality and as many men approached for membership were uncertain as to where they might be located in the near future, because of the war, no concerted drive for new members was made during the year. Nevertheless the number of new members showed an increase over the last few years.

The summary of new members during the last three years are as follows:

	1941	1942	1943
New Members:			
Grade of Member	15	14	20
Grade of Junior	1	2	1
Grade of Student	23	40	42
Reinstated:			
Grade of Member	4	2	5
Grade of Junior	1	4	1
Total	44	62	69

The committee wishes to thank those members of the society not members of the committee who have helped bring in new members.

Respectfully submitted,

ARTHUR E. HARDING, *Chairman*

REPORT OF THE COMMITTEE ON SOCIAL ACTIVITIES

Boston, March 17, 1943

To the Boston Society of Civil Engineers:

The Committee on Social Activities submits the following report for the year 1942-43.

Seven regular meetings were held during the year, six of which were at the Engineers Club and one at the Boston City Club. The total number of members and guests served with supper was 431, an average of 62 per meeting. The average is less by two than for the previous year. An average of four additional persons attended the meetings following the supper.

One hundred and forty-three members and guests attended the Annual Dinner at the Chamber of Commerce Building. This was 28 more than for the previous Annual Meeting. One hundred and ninety-one were served at the Student Night meeting in October at Northeastern University. This meeting included the Student Chapters of the American Society of Civil Engineers at Harvard, Tufts, M.I.T., Brown, Rhode Island State, New Hampshire University, Worcester Polytechnic Institute and the Northeastern University Section of the Boston Society of Civil Engineers. The attendance at the meeting following the supper was increased to 200.

There was no June excursion this year.

A summary of attendance at the various meetings follows:

		Attendance	
		Dinners	Total
March 18, 1942	Annual Dinner Chamber of Commerce	143	143
April 15, 1942	Engineers Club	58	65
May 20, 1942	Engineers Club	46	50
September 23, 1942	Boston City Club	48	50
October 21, 1942	N. E. University	191	200
November 17, 1942	Engineers Club	75	77
December 16, 1942	Engineers Club	84	92
January 27, 1943	Engineers Club	60	72
February 17, 1943	Engineers Club	60	60
Total		765	809

The average attendance at dinners for all 9 meetings was 85, five more than for the previous year. The average total attendance at the meetings was 90, seventeen less than for the previous year.

Respectfully submitted,

JOHN H. HARDING, *Chairman*

REPORT OF THE COMMITTEE ON RELATIONS OF SECTIONS TO MAIN SOCIETY

Boston, March 12, 1943

To the Boston Society of Civil Engineers:

During the past year the committee as a whole has not met, but the activities of the main society and the sections have been more closely knit than usual. There have been three joint meetings, namely with the "Designers Section," the "Sanitary Section" and the "Hydraulics Section." Such joint meetings seem to meet the needs of present emergency and should be carried on for the duration of the emergency.

In this past year, the Sanitary Section held six meetings. The Designers Section held eight meetings, the Hydraulics Section three meetings, the Northeastern University Section nine meetings and the Main Society held nine meetings. There were twenty-nine meetings during the year, with a total attendance of 1805 (less duplicates) or an average of sixty-two per meeting.

The Highway Section held no meetings during the year. Perhaps this Section might prosper as a Transportation Section.

Respectfully submitted,
For the Committee,
CHARLES O. BAIRD, *Chairman.*

REPORT OF THE COMMITTEE ON WELFARE

Boston, March 17, 1943

To the Boston Society of Civil Engineers:

Engineering employment during the entire year was at a high stage, and in consequence no matters have come to the attention of the Welfare Committee for its action. It has not been necessary for the Committee to hold any meeting during the year.

Last year's report contained a statement regarding negotiations whereby the Engineering Societies Personnel Service, Inc., would take over the employment activities of the Emergency Planning and Research Bureau, Inc. These negotiations were consummated during the first half of the calendar year 1942 and since June 1, the employment service of the "Bureau" has been operated by the Engineering Societies Personnel Service, Inc. The manager and the headquarters have been retained as when operated by the Bureau, and our members are urged to use the Engineering Societies Personnel Service, Inc., to solve their employment problems.

Respectfully submitted,
RALPH W. HORNE, *Chairman*

REPORT OF THE LIBRARY COMMITTEE

Boston, March 10, 1943

To the Boston Society of Civil Engineers:

During the past year the Library Committee acquired nine new books with an expenditure of $64.20. In addition, two books were donated by the authors.

The number of books loaned during the year was 122.

The fines collected for overdue books amounted to $5.14.

Following are the titles of the books which were bought:

Who's Who in Engineering—Winfield S. Downs
Mechanical Engineer's Handbook—Lionel S. Marks
Electrical Engineer's Handbook—Archer E. Knowlton
Aerial Bombardment Protection—Harold E. Wessman and William A. Rose
American Highway Practice (2 Vols.)—Lawrence I. Hewes
Water Quality and Treatment—American Waterworks Association
Plastics for Industrial Use—John Sasso
Manuals of Engineering Practice—American Society of Civil Engineers
Manning Formula Tables (2 Vols.)—Horace W. King

The following books were donated by the authors:

Pile Driving Handbook—Chellis
Notes on the Design of Harbor Structures—Fay, Spofford & Thorndike

Respectfully submitted.
EUGENE MIRABELLI, *Chairman*

REPORT OF COMMITTEE ON JOHN R. FREEMAN SCHOLARSHIP FUND

Boston, March 17, 1943

To the Boston Society of Civil Engineers:

In the gift of John R. Freeman of $25,000 to the Boston Society of Civil Engineers, he suggested that the income of the fund be particularly devoted to the encouragement of young engineers in four ways. His chief interest at that time was in provision Four for a travelling scholarship.

The State Department of the United States has announced the suspension, for the duration of the war, of travel grants and other subsidies for United States students abroad.

The other three suggestions are almost, if not quite, eliminated by conditions due to the present emergency.

While the Committee is, therefore, unable to suggest the assignment of any portion of the fund to any immediate use, it realizes the great demand which will probably be made upon it following the war, when accumulated income will be of great service for carrying out Mr. Freeman's plan.

The standing of the Fund is shown in the Treasurer's Report.

Respectfully submitted,

THE FREEMAN FUND COMMITTEE, B.S.C.E.
C. M. ALLEN
HOWARD M. TURNER
ROBERT SPURR WESTON
CHARLES T. MAIN, *Chairman*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION

Boston, March 3, 1943

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year six meetings have been held and papers presented as follows:

March 4, 1942.—"The Sanitary Engineer in the Massachusetts Defense Program," by Mr. Arthur D. Weston. Attendance 54.

April 1, 1942.—"Report of the Committee on Limiting Minimum Velocities of Flow in Sewers," by Mr. Frank L. Flood, Chairman, and Professor Thomas R. Camp. Attendance 27.

June 3, 1942.—"Investigation of Pollution in the Androscoggin River," by Mr. E. Sherman Chase. Attendance 27.

October 7, 1942.—"Sewage Treatment Plant at Ludlow, Mass.," by Henry Taylor. Attendance 26.

January 27, 1943.—"A Complete Sewage Treatment Works for a Population of 53,000," by Mr. Ralph Horne. Attendance 83.

March 3, 1943.—"The Function of Sanitation in the Control of Food Dispensing Establishments," by Mr. F. Wellington Gilcreas. Attendance 60.

The average attendance was 46.
Executive Committee meetings have been held prior to each section meeting.

Respectfully submitted,
For the Executive Committee,
EDWIN B. COBB, *Clerk.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE DESIGNERS SECTION

Boston, Mass., March 5, 1943

To the Designers Section, Boston Society of Civil Engineers:

The following is a list of the meetings which were held during the year March 1942 to March 1943.

March 11, 1942.—Annual meeting and election of officers. Lieut. A. C. Husband spoke on "Navy Building Design at South Boston." Attendance, 40.

April 8, 1942.—Mr. La Motte Grover spoke on "Welded Steel Structures —Design and Construction." Attendance, 35.

May 13, 1942.—Prof. John B. Wilbur spoke on "Beams of Variable Moment of Inertia in Continuous Frames." Attendance, 58.

October 14, 1942.—Prof. Frederick N. Weaver spoke on "Curved Chord Open Panel Frames by Moment Distribution." Attendance, 30.

November 11, 1942.—Mr. William L. Shannon described the design and engineering problems in connection with the recent construction of soil-cement and bituminous concrete pavements under adverse conditions, Portland cement concrete pavements using border-line aggregates, and bituminous surface treated gravel areas at a large war department project in New England. Attendance, 42.

December 16, 1942.—The general subject for this meeting was "Conservation of Critical Construction Materials." This was presented by four speakers on four separate phases of the main subject as follows: Mr. Miles N. Clair—"Concrete"; Prof. Dean Peabody, Jr.—"Reinforced Concrete Construction"; Prof. Albert G. Dietz—"Timber"; and Prof. Walter C. Voss—"Structural Steel." This was a joint meeting with the main Society. Attendance, 92.

January 13, 1943.—Mr. Herman G. Dresser spoke on "Structural Problems of the Sanitary Engineer." Attendance, 36.

February 10, 1943.—Since the scheduled speaker for this meeting could not be present because of illness, the time was utilized for a general discussion. Attendance, 20.

The total attendance at the meetings was 353. The average attendance was 44.

Respectfully submitted.
L. M. GENTLEMAN, *Clerk*

REPORT OF EXECUTIVE COMMITTEE OF THE HIGHWAY SECTION

To the Highway Section, Boston Society of Civil Engineers:

During the past year the section failed to hold any meeting. This was occasioned by inability to secure a suitable speaker due to the emergency. Tentative arrangements have been made to hold a joint meeting with the Massachusetts Highway Association.

Respectfully submitted,
For the Executive Committee,
E. F. Copell, *Chairman*

REPORT OF THE EXECUTIVE COMMITTEE OF THE HYDRAULICS SECTION

Boston, March 10, 1943

To the Hydraulics Section, Boston Society of Civil Engineers:

The following meetings were held during the past year:

May 6, 1942.—Professor Franklin O. Rose spoke on "Concepts Underlying Dimensional Analysis". Attendance 32.

November 4, 1942.—Dr. Kenneth C. Reynolds spoke on "Some Hydraulic Problems near Los Angeles". Attendance 31.

February 17, 1943.—Mr. S. S. Smith spoke on "Mechanical Features of Products Pipe Line Operation". Attendance 42.

The total attendance at the meetings was 105.

The average attendance was 35.

Respectfully submitted,
Harold A. Thomas, Jr., *Clerk.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE NORTHEASTERN UNIVERSITY SECTION

Boston, March 4, 1943

To the Northeastern University Section, Boston Society of Civil Engineers:

During the past year this Section has held the following meetings:

March 13, 1942.—Mr. Harvey B. Kinnison, District Engineer of the U. S. Geological Survey, spoke on "Stream Gaging as Practiced by the U. S. G. S." Attendance, 62.

May 6, 1942.—Chatson Wong, student at Northeastern University, presented a paper on "Geographical and Rectangular Coordinate System in Boston and Vicinity." Attendance, 45.

June 3, 1942.—Mr. H. S. Ashley, Construction Engineer of the Boston and Maine Railroad Company, spoke to the group on "Alteration and Relocation of Boston and Maine Railroad Main Line at Royalston, Massachusetts." Attendance, 15.

October 21, 1942.—Eighty-five Section members attended the Student Night sponsored by the B. S. C. E. and Northeastern Section of the Am. Soc. C. E. at Northeastern University.

November 3, 1942.—Rev. Daniel J. Linehan, S.J., of Weston College, spoke to the group on "Engineering Aspects of Seismology." Attendance, 96.

November 12, 1942.—William E. Savage, student member of the section, showed movies of the Boulder Dam and the Tacoma Narrows Bridge. Attendance, 75.

December 11, 1942.—Mr. Wilbur Connor, Engineer-in-charge of the Hydraulics Laboratory of the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, spoke on "The Hydraulics of Fire Protection." Attendance, 65.

January 8, 1943.—Mr. Howard M. Turner, Consulting Engineer and Lecturer on Water Power Engineering, addressed the Section on "Water Storage." Attendance, 64.

February 12, 1943.—Mr. T. Alfred Fleming of the National Board of Fire Underwriters, spoke to the Section on "Fire Prevention and Protection as Applied to War Plants." Attendance, 65.

The total attendance at meetings was 572. The average attendance was 63.

Respectfully submitted,

HERBERT S. CHURCH, *Clerk*

ADVERTISEMENTS

The advertising pages of the JOURNAL aim to acquaint readers with Professional and Contracting Services and Sources of Various Supplies and Materials. You would find it of advantage to be represented here.

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

INDEX TO ADVERTISERS

COMMITTEES

NOMINATING COMMITTEE

Past Presidents (Members of the Committee)

Arthur D. Weston
Karl R. Kennison
Gordon M. Fair

Charles O. Baird
Frances H. Kingsbury
Frederic N. Weaver
(Term expires March, 1944)

George N. Bailey
Walter M. Fife
Frank L. Lincoln
(Term expires March, 1945)

SPECIAL COMMITTEES

Program

Howard M. Turner, *Chairman, ex officio*

Charles O. Baird
Clarence R. Bliss
Miles N. Clair
Albert G. Dietz
William H. Ellis
Frank L. Flood
Everett N. Hutchins
Harvey B. Kinnison
Harold A. Thomas

Publication

Everett N. Hutchins, *Chairman*

J. Stuart Crandall
Gordon M. Fair
John B. Babcock

Library

Allen J. Burdoin, *Chairman*

Burtis Brown
John C. Coleman
Eugene C. Mirabelli
J. Donald Mitsch
Ralph M. Soule
Frederick N. Weaver

Social Activities

John H. Harding, *Chairman*

Relations of Sections to Main Society

William L. Hyland, *Chairman*

Edgar F. Copell
William F. Covil
Herman G. Protze
Joseph C. Lawlor

Welfare

Ralph W. Horne, *Chairman*

John R. Freeman Fund

Howard M. Turner, *Chairman*

Charles M. Allen
Robert Spurr Weston

Desmond FitzGerald Award

Karl R. Kennison, *Chairman*

Donald W. Taylor
George A. Sampson

Sanitary and Hydraulics Section Award

George A. Sampson, *Chairman*

Harry P. Burden
C. Frederick Joy

Designers Section Award

Karl R. Kennison, *Chairman*

Walter C. Voss
J. Stuart Crandall

Highway Section Award

Donald W. Taylor, *Chairman*

Alexander J. Bone
George A. Graves

Subsoils of Boston

Henry A. Mohr, *Chairman*

Irving B. Crosby
Arthur Casagrande
Charles D. Kirkpatrick
Donald W. Taylor

Investment Committee

Chester J. Ginder, *Chairman*

Howard M. Turner
S. Stanley Kent
Samuel M. Ellsworth