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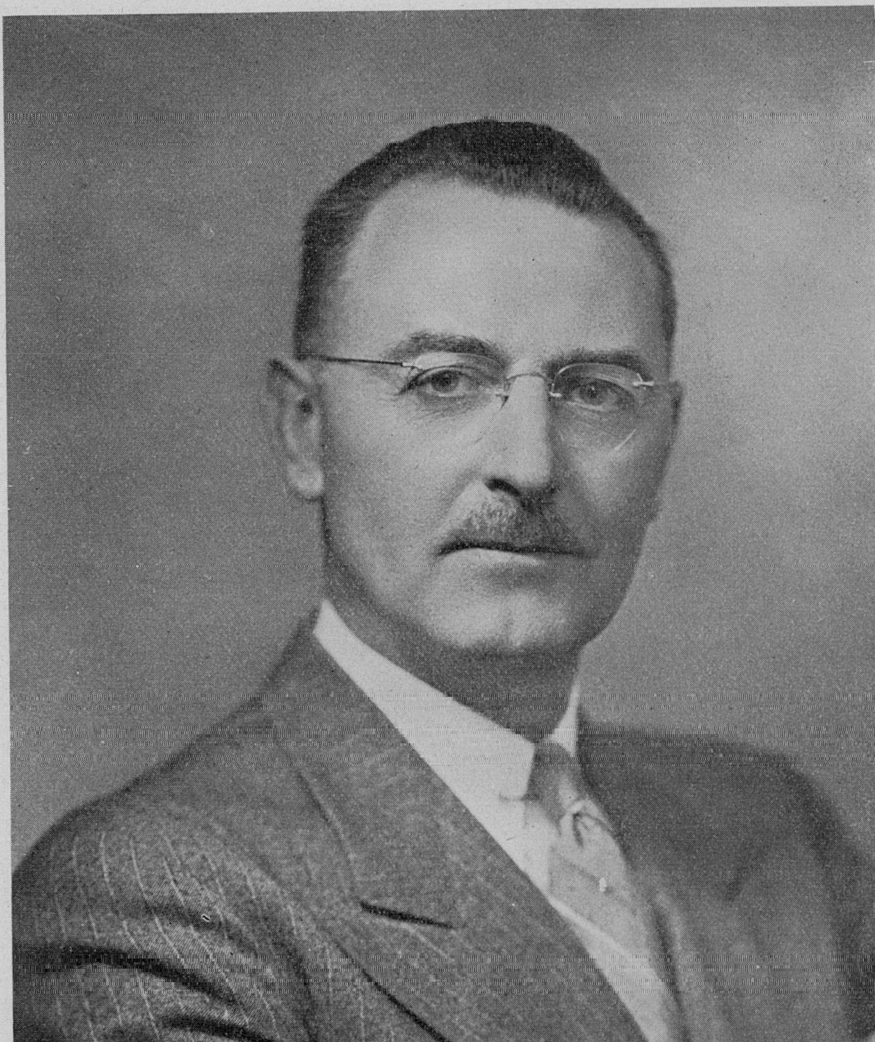

HARVEY B. KINNISON
President
Boston Society of Civil Engineers
1947-48

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CIVIL ENGINEERING — A PROFESSION

PRESIDENTIAL ADDRESS BY GEORGE A. SAMPSON*
Boston Society of Civil Engineers, March 19, 1947.

YOU have sometimes asked yourself as I have, "What is a Civil Engineer?" and "Is he engaged in a Profession, or a Business or just holding down a job?"

The first question can be answered with some degree of assurance. Until about 1875 there were only two classifications for Engineers. He was either a Military or Civil Engineer. Military engineering was the art of planning and constructing works and implements for the destruction of mankind. Any engineer that was not a Military Engineer was known as a Civil Engineer. Civil Engineering was the art of planning, laying out and constructing public and private works for the benefit of mankind. The scope of the Civil Engineer at that time was almost unlimited. He was a "jack of all trades" and good at all.

The distinction between a Military and Civil Engineer was recognized by General Sylvanus Thayer who was mainly responsible for bringing the United States Military Academy at West Point to such a high standing from 1817 to 1833, that he is known as "The Father of the United States Military Academy." When he graduated from West Point in 1808, the Academy offered the only Civil Engineering course in America, a single subject entitled "Civil Constructions." It was not until 1824 that the first civilian engineering school in America was established by Stephen Van Rensselaer, now known as the Rensselaer Polytechnic Institute, and the first class in civil engineering

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was graduated in 1835, thirty-three years after the Military Academy sent forth its first graduate. Then followed the School of Engineering in Union College, N. Y. in 1845, the Lawrence Scientific School at Harvard in 1846; and others in the succeeding years.

In 1871, at the age of 86 and a year before his death, General Thayer founded the Thayer School of Civil Engineering at Dartmouth College. He had long recognized that engineering at West Point would always be subordinated to militarism and that the country was in need of more civilian engineering schools.

When Thayer died in 1872, it was written of him:

"The span of life placed him historically on a divide between two ages: he could look backward to the time when engineering knowledge in Europe and America was possessed mainly by military men and a few expert millwrights: he could look forward to the time when engineering would be the all important pivot on which a new civilization turned."

It is of interest to note that General Thayer was born and died in South Braintree, Massachusetts. For thirty years, from 1833 to 1863 he was engaged in designing and building the fortifications of Boston Harbor.

Probably the best known definition of a civil engineer was written by Thomas Tredgold, an English statesman, more than a century ago, and reads in part as follows:

"Civil engineering is the art of directing the great sources of Nature for the use and convenience of Man." In 1827 this definition was incorporated in the charter of the (British) Institution of Civil Engineers. It is just as true today as it was then and probably always will be.

Charles S. Storrow who graduated from Harvard College in 1829 and studied in the two leading engineering schools in Paris, France, was asked by Dr. Channing, the theologian, upon the completion of his education, "What is a civil engineer?" Storrow answered with enthusiasm, describing the knowledge and qualifications needed to make a civil engineer, when he was interrupted thus: "Hold on Charles, you have told me enough to convince me that no man can ever become a civil engineer." Storrow afterward became a successful railroad builder, creator and manager of the great hydraulic works of the Essex Company at Lawrence, Massachusetts, Consulting Engineer on the Hoosac Tunnel and Honorary Member of the American Society of Civil Engineers.

In 1843 the United States Patent Office stated "The advancement of the arts from year to year taxes our credulity and seems to presage the arrival of that period when human improvements must end."

Our own Society was organized on July 3, 1848, "for the purpose of promoting science and instruction in the department of Civil Engineering." The Constitution states that the objects of the Society are "the professional improvements of its members, the encouragement of social intercourse among engineers and men of practical science, and the advancement of engineering."

It is now pertinent to define a professional engineer. The Regulations adopted by the New Hampshire Board of Registration for Professional Engineers in 1945, contain the following definition in substance:

The term "practice of professional engineering" shall mean any professional service or creative work requiring the applications of advanced knowledge of mathematics and the physical sciences, acquired by professional education and practical experience, involving the constant exercise of discretion and judgment, to such services or work as consultation, investigation, evaluation, planning, design, responsible supervision of construction, and responsible supervision of operation, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works, or projects, wherein the public welfare, or the safeguarding of life, health or property is concerned or involved.

A professional employee (engineer) as defined in Senate Bill S-360 recently introduced by Senator Ball of Minnesota, as an amendment to the National Labor Relations Act is in part as follows: "Any employee engaged in work (i) predominantly intellectual and varied in character, as opposed to routine mental, manual, mechanical, or physical work; (ii) involving the consistent exercise of discretion and judgment in its performance; (iii) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (iv) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual or physical processes."

A profession has been termed a vocation that requires specialized educational training and experience, and renders unprejudiced service to others for a definite fee. Both education and experience are essential. Most of the engineers a century ago were "short" on education and "long" on experience. Possibly the reverse is true today. The engineers of yore were artists, depending on practice and skill in performance. Present day engineers are scientists, having acquired classified knowledge as a tool.

Professional engineering is by no means limited to private practice. He may be engaged in the service of the Government, State or political subdivision, as a professor or teacher in an engineering school, in the industries, in the field of transportation or communication, in the building trade, in the marine or aeronautic branch, in contracting, in research or any other vocation where engineering knowledge and experience is required.

A professional engineer is surely not restricted to a Civil Engineer. Engineering has probably become more specialized than any other profession. Not only do we have Mechanical, Electrical, Chemical, Mining, Metallurgical, and What-Not Engineers, but any of these groups may be divided into smaller divisions. As an example the Civil Engineer may be essentially a Sanitary Engineer and confine his practice almost entirely to the field of water supply and water treatment, or he may be a Structural Engineer specializing in concrete structures or bridges. The trend in engineering is toward a greater use of the sciences and more specialization. The "country doctor" is about extinct in both the medical and engineering profession.

I should like to pay tribute to the Research Engineer. Few scientific truths are discovered by accident. Someone has said, "Patient research, toil and the effort of years constitute the denominator in the fraction which represents the formula of scientific accomplishment and in this fraction the numerator looms large with dreams of hope, of success, and of future achievement. Without hope, without vision, and without dreams success would ever be beyond attainment."

Research is an important field in engineering and will probably gain impetus with the passing years. A notable example is the United States Waterways Experiment Station at Vicksburg, Mississippi, where the problem of flood control in the Mississippi River Valley is being studied by means of a large scale model. There was much indispensable research during the recent world war, including experiments in wind tunnels, plastics, radar, explosives and even the atomic bomb. Professional engineers should have no quarrel with research as it will lead to a quicker answer and result in a more scientific solution of some indeterminate engineering problems than could otherwise be attained.

The professional engineer rightly takes pride in directing his efforts to the benefit of mankind. His training in engineering schools leads to exactness, correct deductions, honesty of purpose, freedom from subterfuge and confidence in his ability. He can keep this faith in himself, the confidence of the public, and the respect of his fellow engineers by holding fast to what he knows is right, by being fair to all and by doing his work well without primary regard to compensation.

In the midst of this engineering-age, I would like to sound a note of caution for the professional engineer. The rapid progress in the sciences and industrial developments has resulted in a marked increase in commercialized engineering. So much so, that in some branches of industry the engineer in private practice has been almost entirely supplanted by a ready-to-wear design of equipment and processes that do not always best meet the conditions. While this tendency may be in the interest of economy, standardization in the field of engineering is sometimes false economy and tends to reduce engineering from a science to an art.

I sometimes wonder if engineering and particularly consulting engineering is becoming too competitive. The tendency seems to be increasing for municipalities to look upon an Engineer as another Contractor and to invite him to submit a bid for his professional services in competition with his fellow engineers on a cost basis. Conceivably, the next step is to advertise for bids from engineers to be received, opened and read at the specified time and place. If this practice is not stopped, the professional engineer will lose his high standing in the community and his own self respect. The remedy rests with the engineer himself. It is not good ethics or for his own best interests to accept an invitation to bid for his services. Do not degrade a learned profession to the status of a business.

After all, the life of the Civil Engineer is one of usefulness, of creating, of doing worthwhile things honestly and economically, not because of the fee that comes with the job, but because of his inborn seriousness of purpose. It rests with us whether Civil Engineering shall be a Profession, a Business or just a job.

THE WATER SYSTEM OF THE CITY OF PHILADELPHIA AND THE PROPOSED SUPPLY FROM UPLAND SOURCES

BY NATHAN B. JACOBS*

(Presented at a joint meeting of the Boston Society of Civil Engineers and Hydraulic Section, B.S.C.E., held on January 22, 1947).

THE most recent report on Philadelphia's water supply was submitted in November, 1946, by the Mayor's Water Commission. This report recommends the adoption of a water supply policy, the lack of which has been the most troubling problem of Philadelphia's water supply for the past century and a half. This report recommends the putting into effect of this policy in three stages. Stage A recommends immediate completion of the rehabilitation of the filtration, pumping, and distribution systems and the installation of additional chemical treatment to eliminate taste and odors. Stage B will include the possible abandonment of the main channel of the Schuylkill River as a source of supply except for reserve purposes and, in lieu thereof, the use of the Delaware River channel to supply all of the water during this stage. Stage C contemplates the obtaining of a supply of upland water for the City of Philadelphia from the Upper Delaware River at a point known as Wallpack Bend, near Bushkill, Pennsylvania, and includes immediate steps to preempt the Wallpack Bend site for Philadelphia's use. This fixing of a considered policy for the water system of Philadelphia fills a gap which has always been missing as a brief review of the history of the Waterworks will easily indicate.

The history of the Philadelphia Waterworks covers a period of a century and a half. It is not unusual to start such a discussion with reference to the last will and testament of Benjamin Franklin, written June 23, 1789, which bequeathed 100,000 pounds for the acquisition of land and the construction of a public waterworks to supply the then City of Philadelphia from the Wissahickon Creek, a small Schuylkill River tributary, which meandered through what is now a well developed and populated part of the City of Philadelphia.

In those days, Engineering was looked upon as one of the Arts; and the ability of a man to develop a public water supply was a matter

*President, Morris Knowles, Inc., Engineers, Pittsburgh, Pa.

of practical experience and inherited ability. It may be assumed that during the decade following the death of Benjamin Franklin, numerous meetings of citizens and discussion groups took place in order to combine and make available the community knowledge of the art of public water supply. The realization of this civic improvement was, no doubt, greatly accelerated by the Yellow Fever epidemic in 1793. Following formal petitions to Councils in 1797, asking for the introduction of a pure water supply into the City, Benjamin Henry Latrobe made a survey for a water supply from Spring Mill and reported to Councils in July of 1798. He submitted reports December 29, 1798 and January, 1799, in which he discussed the construction of an aqueduct from Spring Mill, a water supply from the Wissahickon Creek, and the development of a water power works and impounding reservoirs. His recommendation for the construction of water supply works on the Schuylkill was adopted and the system placed in operation in 1801.

Within ten years, City Council appointed a "Watering Committee" to inquire for a better method of supplying the City. For the next half century, water supply continued to be a community project, but—

> "During 1858, Mr. H. M. P. Birkinbine, Chief Engineer of the Water Department, drew attention to the Wissahickon Creek, Delaware and Lehigh Rivers at Easton, and the Schuylkill River above Reading. After making preliminary surveys of sources near the City, started in 1864, Mr. Birkinbine in 1866 recommended the Perkiomen Creek as a source of supply. The Park Commission in 1867 reported that the Schuylkill River could be relied upon for many years, if properly guarded from pollution. In 1875, a Commission was appointed to investigate the entire subject of the present and future water supply for the City, but owing to the lack of information at their disposal, no recommendations as to the future supply were made.
>
> "During the year 1882, as a result of a prospective water famine, another Board of Experts was appointed. They recommended increasing the capacity of the existing works, also that a thorough investigation of the pollution of the Schuylkill River should be made, and the surveying of all sources for a future available supply. This led to the appointment of a corps of Engineers under Colonel (later General) William Ludlow, Chief Engineer of the Bureau of Water, and a report was made by Mr. Rudolph Hering in 1883-86. Examinations of various areas of the country, comprised within the watershed lines of the tributaries of the Schuylkill and Delaware Rivers in Pennsylvania, were made."

In summarizing the history of the Philadelphia water works, I must acknowledge my indebtedness, not only to the Report of the Bureau of Water of 1909, entitled "Description of the Filtration

Works and Pumping Stations, also Brief History of the Water Supply", from which the above paragraphs are quoted, but also to the History of the Water Works and Annual Report of the Chief Engineer of the Water Department, Wm. B. McFadden, presented to Councils in 1860; the Report of the Water Department for the year 1875 which presents a rather complete chronological statement of "Important Events Connected with the Water Works of Philadlephia"; and the more recent paper of Seth M. Van Loan, Chief of the Bureau of Water, before the College of Physicians of Philadelphia, April 29, 1940, on the "Early History of the Philadelphia Water Supply."

The Final Report of Rudolph Hering, Engineer-in-charge of the Surveys for the Future Water Supply of the City of Philadelphia, is to be found in the 1886 Annual Report of the Water Department. It is published as Appendix H. Mr. Hering took it "for granted from the outset, that the water from any point in the Schuylkill River, and from any point in the Delaware River, below Trenton, will not be of sufficiently good quality to furnish a future supply for the City, although the fact has been admitted that, at present, the Delaware water at Lardner's Point, within the City limits, is not only fairly good, but is likely to remain so for some time . . . nor would filtering or purifying the water of the Schuylkill or Lower Delaware give permanent satisfaction. The only schemes worth investigating were those which bring to the City the water of running streams in the Schuylkill, Delaware, and Lehigh watersheds." (Final Report of Rudolph Hering, July, 1886, pp. 308-9).

Rudolph Hering was one of America's most eminent waterworks engineers but, nevertheless, on October 26, 1886, or within four months from the submission of his report, he felt it necessary to write the Chief Engineer of the Water Department because he had "heard that a proposition was to be urged recommending the diversion of the Tohickon water into the Perkiomen valley, and having considered this scheme over a year ago, and rejected it. . . ." However, the really significant event in connection with the submission of the Hering report is that the same volume which publishes his report as Appendix H, carries as Appendix I, an Address on the Schuylkill River as a Source of Water Supply for the City of Philadelphia, by a physician who states "with great deference to the opinions of the other side, having heard these opinions, and attaching to them all the importance they deserve, that putting them alongside of other opinions of gentlemen of equal ability and responsibility, I have come to the conclusion that there is no difficulty in preventing any pollution of the Schuylkill River, either within or without the City limits. For all these reasons, I think I am justified in saying that the Schuylkill River is the proper source of the Future Water Supply of the City of Philadelphia." Then follows Appendix K, which is an extract from proceedings of the Water Committee at a meeting held in Select Council Chamber on the evening of January 13, 1887, quoting the address of another Philadelphian who states, "I would, therefore, on behalf of our Citizens' Committee, urge the continued use of the Schuylkill as our main source of water supply, and suggest the above means by which its quality and availability may be improved." This same citizen also submitted "a plan of the canals and reservoirs of the Schuylkill Navigation Company, prepared by and belonging to Mr. E. F. Smith, who has kindly permitted its use by our Committee. This shows the six weeks' supply contained in the reservoirs, etc., of the Company." These opinions evidently controlled instead of the engineering report and the City continued to obtain its supply of water from the Schuylkill and Delaware Rivers.

On October 7, 1897, Thomas M. Thompson, Director of the Department of Public Works, addressed a communication to the Committee on Water on the subject of Water Supply and Filtration. This report was requested by a resolution of Select Council, relating to the subject of Future Water Supply and Filtration thereof.

On September 9, 1898, John C. Trautwine, Jr., Chief of the Bureau of Water, submitted his Report with Plans and Estimates of Cost for proposed slow sand filter beds in connection with the Spring Garden pumping station and East Park Reservoir, Roxborough, Belmont, and Frankford, and a proposed rapid sand filter plant at the Queen Lane Reservoir.

This report was followed by the Report on the Extension and the Improvement of the Water Supply of the City of Philadelphia by a Commission composed of Rudolph Hering, Joseph M. Wilson, and Samuel M. Gray, and as a direct result of this report, the construction of purification works, pumping stations, supply mains, and appurtenances to furnish a filtered water supply to the City of Philadelphia was undertaken in 1901 and completed in 1913.

Thus the final decision was for a filtered water from the Schuylkill and Delaware Rivers and the original units of the system, with certain modifications and minor improvements, have since continued to supply the water needs of the City.

In this historical review of events leading up to the development of the present water supply system, there is an indication of one phase of the Philadelphia water problem. In each report, and in each decision with regard to improvement, there is evidence of a conflict of opinion concerning the utilization of nearby sources and the development of a more remote supply. This conflict of opinion appears not only with respect to different groups but in the minds of the same persons at different dates. For example, the report of Rudolph Hering in 1886, as Engineer-in-Charge of the "Surveys for the Future Water Supply of the City of Philadelphia", as contrasted with the final adoption of a filtered water supply from the Schuylkill and Delaware Rivers which was recommended in the "Report on the Extension and the Improvement of the Water Supply of the City of Philadelphia", submitted in 1899 by a Commission of three, of which Mr. Hering was one.

This indecision and doubt as to the wisdom of continuing and improving the facilities for obtaining water from nearby sources or of developing a more distant supply has continued. Although the program of filtration of the Schuylkill and Delaware Rivers was only completed in 1913, a further report considering the advisability of continuing to obtain water from these sources or of developing an upland supply was submitted in 1920 by a Board of Consulting Engineers. This Board was composed of Messrs. Ledoux, Fuller, Hasskerl, and Smith, and recommendation was made for the construction of the first impounding reservoir on the Perkiomen and improvement of the existing Delaware and Schuylkill River supplies.

Since 1920, there have been many reports on Philadelphia's water supply problem including, among others:

- 1922 The Water Supply Problem of Philadelphia by the Bureau of Municipal Research.
- 1924 Reports of the Water Commission on May 29 and September 18.
- 1926 Report on the Philadelphia Water Shortage by J. W. Ledoux.
- 1932 Regional Plan of the Philadelphia Tri-State District, containing Chapter X on Water, Supply and Sanitation.
- 1933 Report on the Delaware River, made under the provisions H. D. No. 308, 69th Congress, containing Section VII on Water Supplies.
- 1936 Report to the National Resources Committee on the Delaware River Basin.
- 1937 Report of the Technical Committee on the Study of the Water Supply Project of the City of Philadelphia.

1938 Bureau of Water-Structures showing extensions and improvements as submitted to the Philadelphia Authority on September 28.

1940 Report on Proposed Extension, Improvement and Rehabilitation of Water Supply System of City of Philadelphia by Morris Knowles Incorporated.

1945 Preliminary Report to the Philadelphia Water Commission on a New Water Supply from Upland Sources, by a Board of Consulting Engineers composed of Messrs. Emerson, Friel, Jacobs, Justin, and Requardt.

1946 Report to Philadelphia Water Commission on the Development of an Upland Source of Water Supply and Suitability of Existing Sources of Supply with Augmented Facilities, by the Board of Consulting Engineers.

In arriving at this long-range policy, the Mayor's Water Commission had before it not only the reports just referred to, but was also furnished with reports from interested citizens and groups, including:

1945

Dec. 3—Report Upon Various Legal and Practical Aspects of the Yardley-Wallpack Bend Project, by Charles E. Ryder.

1946

Jan. 11—Report on Water Supply from the Upper Lehigh River, by Gannett, Fleming, Corddry and Carpenter, Inc.

Jan. —On the Adequacy of an Unfiltered Water Supply from Upland Sources to be Impounded in Huge Reservoirs Holding Many Months of Consumption, by Thomas H. Wiggin.

Jan. —Pocono Mountain Water Supply for Philadelphia, by William P. Creager.

Jan. —Pocono Mountain Water Supply for Philadelphia, by Ford Kurtz.

Jan. 22—A Water Supply from the Upper Lehigh, by Board of Consulting Engineers.

June —Philadelphia's Water Supply and Analysis and Program, by Robert K. Sawyer, Bureau of Municipal Research of Philadelphia.

June 4—Proposed Trenton-Warrington Project for Philadelphia Water Supply, by Professor William S. Pardoe.

June 5—Report on Municipal Water Supply, by Northeast Philadelphia Chamber of Commerce.

July —Report on Improvements to Existing Filtration Plants to Provide for Taste and Odor Control, by Martin J. McLaughlin, Director, Department of Public Works.

Aug. 1—Report of Special Committee of Chamber of Commerce and Board of Trade of Philadelphia Appointed to Study the Problem of the Water Supply for Philadelphia.

In the light of past events, it is apparent that one very serious phase of Philadelphia Water Supply has been the lack of a clear-cut, definite program of development. This recent report is an attempt to set up a long-range policy for the development of the City's Waterworks in three stages.

PRESENT SYSTEM

The present waterworks system of Philadelphia is in general conformity with a comprehensive program for development adopted in 1899 which included retention of the existing sources of water supply obtained from the Schuylkill and Delaware Rivers and the construction of filter plants rather than development of a "mountain supply" which had previously been advocated in various reports. Filtered water has been supplied throughout the City since 1912, and, with exception of relatively minor improvements, the original pumping and filtration facilities remained unchanged, until the present program was started in 1940.

Approximately 325 million gallons of filtered water are furnished each day to the City's 2,000,000 population, and varied industries. At the present time, about half of the total supply is taken from the Schuylkill and half from the Delaware River.

Purification facilities comprise five filter plants, one of which at Torresdale takes its supply from the Delaware River and the remaining four, known as the Belmont, Queen Lane, Upper Roxborough, and Lower Roxborough plants, are supplied water from the Schuylkill. There are ten filtered water storage basins, five raw water and eight filtered water pumping stations, and about 2,500 miles of distribution mains of all sizes up to 93 inches in diameter, including some 30,000 valves and over 20,000 fire hydrants. All industrial and commercial consumers and about 50 per cent of the domestic consumers are metered.

Water from the Schuylkill is pumped by the Belmont and Queen Lane Stations, located above Fairmont Dam, to large sedimentation basins at filter plants of the same designation, and by the Shawmont Pumping Station, located above Flat Rock Dam, to a sedimentation basin at the Lower Roxborough filter plant. From here a portion of the settled water is repumped to the Upper Roxborough filter plant. The Belmont and Shawmont Stations are completely electrified while the pumps at Queen Lane Station are driven by high-pressure steam turbines.

Water from the Delaware River is taken from the tidal basin at Torresdale by a completely electrified low head pumping station and discharged to the adjacent filter plant.

All raw water pumping stations have been subject to partial modernization and the present waterworks improvement program includes further rehabilitation, particularly with respect to the facilities at Queen Lane which are now in process of electrification. Shawmont Station ultimately will be abandoned.

The five filter plants in the present system provide varying types of treatment ranging from single filtration by slow sand filters at the two Roxborough plants to double filtration, including supplementary chemical treatment, at the Torresdale plant. The sedimentation basins preceding the filters of the four Schuylkill filter plans were originally used for distribution of raw water to the consumers prior to construction of the present filter plants.

The Upper Roxborough plant, having a nominal capacity of 20 m.g.d., and the Lower Roxborough plant, having nominal capacity of 10 m.g.d. employ single filtration by slow sand filters and chlorination of the filtered water. Both plants will be abandoned and the areas which they now serve will be supplied from the Queen Lane filter plant.

The Queen Lane filter plant has a nominal capacity of 100 m.g.d., of which 50 per cent is twice filtered, first through pre-filters of the rapid sand type and then through slow sand filters. The remainder of the supply from this plant is pre-chlorinated, clarified by sedimentation with alum as a coagulant, passed through rapid sand filters, and combined with the output of the slow sand filters prior to final chlorination and distribution. It is proposed to increase this plant to 120 m.g.d. capacity under the current improvement program and provide modern coagulation together with facilities for double filtration of all water.

The Belmont filter plant has an aggregate capacity of 70 m.g.d. of which 40 million gallons are purified by slow sand filters and the remainder by rapid sand filters. Alum and chlorine are applied ahead of the rapid sand filters and all water is chlorinated after filtration. It is proposed to reconstruct this plant to provide for double filtration of all water.

The Torresdale filter plant has a capacity of 200 m.g.d. and provides double filtration of the entire output. Auxiliary treatment consists of coagulation of the water in the tidal basin before pumping to the pre-filters. Provision for application of chlorine is made between the tidal basin and the pre-filters. The water is again chlorinated at the clear well before distribution. The present waterworks improvement program contemplates replacement of the existing pre-filters with modern coagulating facilities and a rapid sand filter plant discharging to the present slow sand filters. Overall capacity will be increased to 260 m.g.d.

The entire water supply of the City must be pumped in order to develop pressures adequate for distribution.

In the case of the Schuylkill water, this pumping occurs before filtration and permits most of the filtered water to be delivered to consumers by gravity except for about 20 per cent of the combined filtered water production at the Belmont-Queen Lane-Roxborough facilities which is repumped by a number of scattered booster stations to points in West and Northwest Philadelphia. Some of the booster stations are currently planned for rehabilitation or reconstruction in new locations and a few new stations will be added to the system.

All water from the Delaware River channel, after filtration at Torresdale, is distributed by direct pumping at the Torresdale and Lardner's Point pumping stations. The former station handles about 5 per cent of the total filtered Delaware supply and its capacity will soon be incorporated into the new 212 m.g.d. Torresdale filtered water pumping station now under construction at this location. The Lardner's Point station has been operated for many years by steam power with a combination of triple expansion engines and steam turbines. This equipment is being replaced by electric motor driven centrifugal pumping units, aggregating 210 m.g.d. capacity. When completed, the station will operate with the new Torresdale filtered water pumping station on a complementary basis. Both stations will continue to serve that area generally east of Broad Street with filtered Delaware River water.

The total capacity of reservoirs for storage and distribution of filtered water approximates 890 million gallons including about 190 million gallons clear well capacity at the various filter plants. With the exception of the 50 million gallon capacity clear well at Torresdale, all filtered water storage is located at elevations which permit gravity distribution. When the Roxborough filter plants are abandoned, the present sedimentation basin will be converted to filtered water storage which will increase filtered water storage capacity to 1,037 million gallons or about 3-1/3 days' supply on the basis of current requirements. The only new construction of storage facilities planned at this time are elevated tanks of one million gallons' capacity each to meet peak demands in the Chestnut Hill, Fox Chase, and Somerton areas.

The distribution system is subject to constant extension and reinforcements with the growth of the City and changes in location of areas of concentrated demand. The waterworks improvement program contemplates considerable main construction to meet such situations as well as general minor installations throughout the City to improve service to consumers. The waterworks improvements currently being constructed were originally planned in 1940 as a general program of rehabilitation to utilize advances in science of water purification for coping with increased pollution of raw water supply and to provide capacity to meet the needs of the City to about 1965, but this program was deferred due to the defense program and the War. Temporary measures were taken to continue an adequate supply of water to take care of the additional load put on the system by the war industries. When this program of waterworks rehabilitation is completed, the system generally will include:

(a) Raw water pumping capacity of 665 m.g.d. of which 365 m.g.d. will be on the Schuylkill, apportioned between the Belmont and Queen Lane Stations, and 300 m.g.d. on the Delaware River at Torresdale.

(b) Purification facilities aggregating 450 m.g.d. capacity of which 190 m.g.d. will be allotted to the Belmont and Queen Lane filter plants and the remaining 260 m.g.d. to the Torresdale filter plant. In all cases, facilities will provide for modern pre-treatment of the water, double filtration, post-chlorination, and corrosion control.

(c) Filtered water pumping capacities will be in the neighborhood of 750 to 800 m.g.d. including main and district station installations. The final figures have not as yet been determined.

(d) Filtered water storage, including distributions reservoirs and filtered water reservoirs at filtration plants, will be increased to a total of 1,037 million gallons by conversion of the 147 million gallon sedimentation basin at the Lower Roxborough fiter plant. This is equivalent to approximately 2-1/3 days' supply at present rates of consumption or about 2-1/2 times requirements of maximum days.

(e) Distribution system improvements, reinforcements, and alterations will provide distribution of water at more uniform pressures and adequacy during periods of high demand into rearranged distribution districts.

In 1940, at the same time that the waterworks rehabilitation program was started, a contract was made with Ozone Process Incorporated to experiment with the use of ozone to eliminate taste and odors in the raw water, some of which were accentuated by the use of chlorine. As a result of these experiments, and the desire of the Water Commission and City Council to try out the use of ozone on a plant scale, a contract has just been awarded for furnishing and installing a complete Ozonation System to deliver 1,250 pounds of ozone per day, adequately and satisfactorily and to apply the same to an average quantity of 36,000,000 gallons per day of the raw water which will be subsequently filtered through the rapid sand filters at the Belmont plant.

Upland Sources of Supply.

The reports of the Board of Consulting Engineers to the Philadelphia Water Commission have dealt mostly on that section of the Water Commission's report designated as Stage C, which contemplates going to upland sources.

For a supply of the magnitude required for Philadelphia and in consideration of probable time required for the design and construction of such project, cities should be placed on an ensuing period of not less than 50 years or until about the year 2000. The population of the City in 1940 was 1,931,334, a decrease of 19,627 below the 1930 census. However, an estimate made in January, 1945, based upon issuance of War Ration Book No. 4 indicated a population of over 2,000,000. Using the 1940 census as a basis and employing the indicated rate of increase to the year 2000, the City would, in that year, have a population of about 2,180,000. If the percentage values indicated for the Tri-State Districts should be applied to the City, the resulting figure for the year 2000 would be about 3,600,000. Similarly, the rates of increase for the United States as a whole, if applied to the City, would give a population of about 2,620,000 for the year 2000. Much thought and study have been given to population statistics as to the comparative growth of cities, as well as suburban and rural areas, but for the purposes of water supply, it was felt that a reasonable estimate of population for the City of Philadelphia for the year 2000 would be 2,400,000.

Philadelphia currently utilizes water at the average rate of 180 gallons per capita per day, based upon raw water withdrawal from the rivers. This is more than New York City which shows a water usage of 137 gallons per capita daily, Baltimore with 152 gallons per capita, and Cleveland with 178 gallons per capita. If the present consumption rate of 180 gallons per capita is applied to an estimated 2,400,000 population for the year 2000, a water supply development capable of supplying 430 million gallons daily would suffice. In view of the uncertainties as to future developments, it did not seem unreasonable that for the purpose of study the upland water supply should be capable of producing 500 million gallons per day. Incidentally, this is the same figure which has been used by practically all other boards and commission which have studied the problem during the past 30 years.

All of the upland sources considered were capable of yielding a water of safe and acceptable quality. An old French text, published in 1784, had this to say concerning the quality of drinking water: "Drinking waters may be easily known by the following character: they have a brisk, sharp taste; they have no smell; they boil easily; they cook pot herbs well; they dissolve soap without forming lumps; they deposit nothing or very little by test." In other words, in those days a good water was one that tasted well and cooked well, a sort of Epicurean standard. A public water supply, to meet domestic and industrial requirements, should be free from pathogenic organisms, attractive in appearance, odorless, colorless, clear, non-corrosive, palatable, and soft.

The waters from various upland sources of water supply were observed and analyzed and from the data thus obtained, the conclusions were reached in regard to their acceptability. All waters from the sources considered would, in the judgment of the Board of Consulting Engineers, require filtration in order to give a product that is both safe and satisfactory. Treatment would not be required to reduce hardness. Growths of micro-organisms in storage reservoirs must be expected, and methods for the treatment and for the removal of attendant tastes should be provided.

All of the streams considered are tributaries of the Delaware River and, therefore, subject to Federal and State laws and regulations pertaining to the diversion of inter-state streams and tributaries thereof. In setting up hydraulic criteria for these water supplies, the Board was mindful of the decision of the United States Supreme Court in the New York Water Supply case and the statutes of the States of New York and New Jersey and the Commonwealth of Pennsylvania. The Supreme Court granted New York the right to divert the equivalent of 440 million gallons daily upon the condition, among others, that at any time should the flow of the Delaware River at Port Jervis or at Trenton fall below 0.50 cubic feet per second per square mile, water should be released from the New York storage reservoirs in volume sufficient to restore the flow to this figure, except that such releases need not exceed 30 per cent of the diversion area yield.

This rule differs from the release requirements set by the Commonwealth of Massachusets when the Metropolitan Water Supply Commission was given the power to divert two tributaries of the Connecticut River, the Ware and the Swift, into the Wachusett Reservoir.

The Ware River diversion permitted the use of the flow of the stream in excess of 85 million gallons which is equivalent to 1.34 cubic feet per second per square mile from the 98 square miles of drainage area affected. This flow of 1.34 cubic feet per second is several times the average dry weather flow of the Ware River, and no water was to "be so diverted between May 31 and December 1 in any year, unless such diversion be first approved by the State Department of Public Health."

A different rule was used for the Swift River. There the Commission was required to maintain a flow of 20 million gallons a day at Bondville where the drainage area is about 195 square miles. This is a guaranteed flow of 0.16 cubic feet per second per square mile. However, the Commission accepted the recommendation of the Chief of Engineers and the Secretary of War, whereby the releases from the Swift River were augmented during the critical period for navigation from June 1 to November 30 so that the rate of discharge from the Swift should be 70 cubic feet per second when the Geological Survey gage at Sunderland, Massachusetts, was less than 4,900 cubic feet per second, equivalent to an average lower low tide gage height of 2.1 at Hartford, Connecticut, and 110 cubic feet per second on such days as the Geological Survey gage at Sunderland, Massachusetts, indicated a discharge of the Connecticut River at that point of 4,650 cubic feet per second or less, equivalent to a gage height at Hartford, Connecticut, of 2.0.

To comply with the rules and regulations of the Inter-State Commission on the Delaware River Basin, the Pennsylvania Water and Power Resources Board and the decision of the United States Supreme Court governing release of water for use and benefit of downstream communities and individual riparian owners and users of water and water power, the Board adopted the following formula:

> Whenever the flow of the stream is equal to or less than 0.6 cubic feet per second per square mile of watershed area above the point of development, all the natural flow of the stream shall be released.
>
> Whenever the natural flow of the stream at the point of development exceeds 0.6 cubic feet per second per square mile of watershed area above the point of development, at least 0.2 cubic feet per second per square mile shall be released.

This formula provides releases somewhat greater than the minimum requirements of Inter-State Commission on the Delaware River Basin and insures against reduction of low stream flows below the dam similar to rule for the Ware and Swift Rivers. The water delivered to Philadelphia, therefore, will be from the higher and flood flows of the stream.

The Board of Consulting Engineers reported to the Water Commission on 6 separate projects, 4 of which were selected by the Commission; the other 2 were adaptations or alternates to the Commission's selections. All of them developed water supplies from the Delaware River Drainage Basin, either from the main channel or from tributaries of the Upper Delaware, of the Lehigh, and of the Schuylkill.

Delaware River Yardley Project

The Delaware River Yardley Project provides for a supply of 500 million gallons of water a day to Philadelphia from an intake on the Delaware River near Yardley, about six miles above Trenton; from four storage reservoirs on the watershed of Perkiomen Creek and from a storage reservoir on Tohickon Creek.

Water from the Perkiomen reservoirs, augmented by diverted flow from the Tohickon reservoir, would be delivered through concrete lined tunnels, deep in ledge rock, to the existing raw water sedimentation basin of the Queen Lane filter plant. From Queen Lane, a portion of the water would be pumped to the raw water sedimentation basins of the Belmont filter plant and to Roxborough. Thus, filtered upland water instead of filtered Schuylkill water would be supplied to that portion of Philadelphia generally west of Broad Street.

Water from the Yardley intake would be delivered by gravity through a tunnel in ledge rock to the existing tidal basin of the Torresdale filter plant and, by low lift pumping, would be raised to new coagulating basins which are contemplated for installation at Torresdale under the present waterworks improvement program. Thus, water from Yardley, after filtration at Torresdale, would be supplied to that portion of Philadelphia generally east of Broad Street.

Reservoirs would be located as follows:

Green Lane—on the Perkiomen Creek near Green Lane.
East Swamp—on Unami Creek (Tributary of the Perkiomen).
West Swamp—on West Swamp Creek (Tributary of the Perkiomen).
North East Branch—on North East Branch of Perkiomen.
Tohickon—on Tohickon Creek. The yield of this reservoir would be diverted by tunnel into the drainage area of the North East Branch of the Perkiomen.

The safe yield from the Perkiomen-Tohickon supply is computed at 166 million gallons a day, which is adequate to meet the estimated future demands of the Queen Lane-Roxborough districts.

Average daily requirements for the Torresdale supply district, therefore, become 334 million gallons a day, which will be met by the new Delaware River intake works at Yardley. During the 13 years embraced in the "Incodel" period, used as a basis for hydraulic computations in this report, the minimum flow of the Delaware at the Trenton gaging station was 790 million gallons a day (1,220 c.f.s.). The average flow for the period from February, 1913 to September, 1942, was 7,450 million gallons a day (11,350 c.f.s.). The diversion of 334 million gallons of water daily by Philadelphia to meet average daily requirements would represent 42 per cent of the observed minimum daily flow and 4.5 per cent of the average flow. Diversion to meet the requirements of maximum days would represent 51 per cent of the observed minimum daily flow and 5.4 per cent of the average flow.

The Delaware River Yardley Project in common with other sources of upland water supply investigated, is reasonably free from pollution; possesses only moderate hardness; can be adequately and satisfactorily purified by the existing filter plants, after completion of the present waterworks improvement program; will effect a material saving in present raw water pumping costs and will supply an adequate volume of water for future needs of the City.

It is derived from two widely separated districts so that in event of catastrophe destroying either sources of water supply, or related conduits, the City would not be deprived entirely of drinking water.

It is subject to piecemeal construction so that a new source of raw water supply could be provided for the filter plants of either the Schuylkill or Delaware distribution districts, if desired.

Delaware River Project (Wallpack Bend)

This project provides for supply of 500 million gallons of water a day to Philadelphia and involves construction of a dam in the northeasterly course of the great "S" curve of the Upper Delaware River at Wallpack Bend near Bushkill, Pennsylvania; a regulating reservoir in the vicinity of Warrington, Bucks County; and tunnels to deliver water by gravity to the regulating reservoir, and thence to the site of the present Queen Lane filter plant for purification.

In development of this project, inspections were made of all dam sites on the Delaware River considered practicable for use as a source of water supply for the City. Particular attention was given to six locations through field investigations and office studies, and independent investigations were made by a Geologist.

The East and West Branches of the Delaware River have their source in the Catskill Mountain region, at elevation above 2000, and unite near the New York-Pennsylvania boundary to form the main river. The course then is in a generally southeasterly direction to Port Jervis where the river makes a sharp bend to the southwest and continues in that direction to a short distance below the mouth of the Lehigh, where it again changes direction and continues southeasterly to below the head of tidewater at Trenton and thence southwesterly to Delaware Bay.

In the upper portion of the watershed, the topography is mountainous and contains numerous lakes and ponds. Below the Water Gap, where the river cuts through the Kittatinny Ridge, the valley gradually widens and the precipitous sides become gently sloping hillsides.

Above Wallpack Bend, the furthest upstream dam site considered, the watershed is mostly forest land and only two of the scattered municipalities are of any considerable size. (Honesdale, population about 6,000 and Port Jervis, population about 11,000.) In this area, the density of resident population is only about 31 persons per square mile. Between Wallpack Bend and Belvidere, the furthest downstream dam site considered, the watershed is more highly developed and the river receives drainage from Stroudsburg and East Stroudsburg, having a combined population of about 13,000 persons and from several other sizeable municipalities with populations ranging to about 5,000. The summer population on the watershed is much greater than the permanent population because of the thousands of visitors to this great recreational area.

An alternative to the Delaware River Project would comprehend the elimination of some 32 miles of conduit extending from the Wallpack Bend Reservoir to a point near Easton, above the mouth of the Lehigh, and the construction of a diversion dam, intake works, and pumping station at that point. Water released from the Wallpack Bend Reservoir would flow down the channel of the river to near Easton, where it would be pumped through a concrete lined tunnel to the Warrington Regulating Reservoir and thence flow by gravity to the City. This alternative would require less tunnel but the addition of a diversion dam and pumping station would be necessary. The net effect would result in a considerably lower construction cost. The capitalized cost of the necessary pumping, however, would offset, to some extent, the saving in construction cost. This construction could be considered as a step in the ultimate plan for development of the Delaware River Project.

The volume of water available from Wallpack Bend Reservoir would be adequate for the estimated future needs of the City.

The water would be much softer than that now obtained from the Schuylkill and contamination would be much less than that of present raw water supplied to the City's filter plants. It could be adequately purified by sedimentation and filtration. About 85 per cent of the total water requirements of the City could be delivered to the existing filter plants by gravity and pressures for pumping the water from Queen Lane filter plant to Belmont and Roxborough would be much less than now required for furnishing raw Schuylkill water to these three plants. Delivery of the raw water supply through tunnels deep in ledge rock constitutes a greater safeguard against interruption of supply than by delivery through force mains having shallow coverage such as those now in use.

The chief disadvantage of the Delaware River Project is its distance from Philadelphia, about 80 miles of tunnel being required which is reflected in its relative cost. The inter-state character of the project will necessitate a treaty between Pennsylvania and New Jersey.

Yardley-Wallpack Bend Project

The Yardley-Wallpack Bend Project is an alternate method for development of the Upper Delaware River.

It provides for supply of 500 million gallons of water a day to Philadelphia and involves construction of a storage dam and reservoir at Wallpack Bend; a low diversion dam and intake at Yardley, Pennsylvania; a gravity flow tunnel from Yardley to a raw water pumping station in the vicinity of Hulmeville; a pressure tunnel to convey water from Hulmeville to a regulating reservoir in the vicinity of Warrington and thence by pressure tunnel to Queen Lane filter plant; and a pressure tunnel from Hulmeville to the Torresdale filter plant. The Wallpack Bend dam and impounding reservoir, the Warrington dam and regulating reservoir, provisions for release of water for benefit of lower riparian owners and users and other hydraulic and design criteria are the same as just described for the Delaware River Project. The essential difference of this project is the use of the channel of the Delaware River for delivery of water from Wallpack Bend Reservoir to Yardley, and thence by pumping and tunnels to the City. It sacrifices the available head at Wallpack Bend which is utilized in the other project to deliver water by gravity through pressure tunnels to Warrington and Queen Lane.

The possibilities for development of hydro-electric power at the Wallpack Bend dam are enhanced in this project because additional water representing Philadelphia's supply must pass through the dam for transit down the Delaware to Yardley.

Near Yardley, at a point about 1,100 feet upstream from the present highway bridge, a low diversion dam would be constructed across the river. Crest of the dam would be at elevation 16 (U.S.G.S.) and would increase surface level of the river about two feet at low water stages. At higher stages of the river, the dam would have no appreciable effect on elevation of the water surface. The structure would be designed with a rather flat upstream slope to facilitate movement of ice downstream and prevent excessive pressure against the dam.

The intake would be located along the Pennsylvania shore of the stream about 500 feet above the dam and would connect with a shaft leading to a 15′-6″ diameter pressure tunnel through which the water would flow by gravity to a pumping station near Hulmeville.

A dual purpose pumping station would be constructed along

Neshaminy Creek in the vicinity of Hulmeville for delivery of raw water from Yardley to the Torresdale rapid-sand filter plant proposed under the current waterworks improvement program and to the regulating reservoir at Warrington from whence it would flow by gravity to Queen Lane through pressure tunnel.

The pumps for water delivery to Torresdale would be low-lift equipment for operation against a head of about 64 feet. Total installed capacity would be approximately 500 m.g.d. to assure continuity of service for an estimated 330 m.g.d. average consumption.

The pumps for water delivery to Warrington would operate against a head of about 312 feet and the installed capacity would approximate 250 m.g.d. to provide continuity of supply for an estimated consumption of 170 m.g.d.

As an adjunct to pumping station operations, the discharge pressure tunnels to Torresdale and Warrington would be inter-connected at Hulmeville so that advantage would be taken of the large storage in the Warrington regulating reservoir which could flow back to Torresville by gravity should the low-lift pumps or the Yardley-Hulmeville tunnel be taken out of service.

The advantage of this project would be the supply of soft Delaware River water throughout the City and the saving in cost through the omission of the tunnel from Wallpack Bend Reservoir to Warrington, as required by the Delaware River Project. This saving in construction costs would be partially offset by pumping costs.

An additional advantage which this project shares with the Delaware River Project is the facility with which the quantity of supply may be enlarged through the construction of additional storage reservoirs on the watershed of the Delaware River.

The disadvantages of the project would be the failure to utilize the available head at Wallpack Bend for delivering a gravity supply to Philadelphia, and also the fact that the raw water available to the filters will be less desirable in quality than if transported in a closed conduit from Wallpack Bend to the regulating reservoir at Warrington.

Upper Delaware River Basin Tributaries Project

The Upper Delaware River Basin Tributaries Project provides for supply of 500 million gallons of water a day to Philadelphia from reservoirs to be constructed on six tributaries of the Delaware River draining the Pocono region (Lackawaxen River, Shohola Creek, Bushkill Creek, Broadheads Creek, McMichaels Creek, and Buckwha Creek). There will also be required, a regulating reservoir on Unami Creek in the western portion of Bucks County and pressure tunnels for collecting the flow from the various storage reservoirs and for delivery by gravity from the Unami regulating reservoir to the existing raw water sedimentation basin at Roxborough. Branch conduits for delivery of raw water to other filter plants of the City will also be required.

The watersheds of all streams composing the project are situated in Pennsylvania. With exception of the Lackawaxen which furnishes more than one-half of the total supply, all the streams have relatively small drainage areas and some require relatively high and expensive dams to provide storage sufficient for regulation of flows.

The advantage popularly ascribed to water derived from the Pocono region is that of a pure, soft mountain supply, not requiring filtration or other treatment and entirely available to the City without pumping. It was found that the water is somewhat polluted and at times highly colored, so that filtration would be essential to provide a safe and satisfactory supply. There is left then only the advantage of being able to supply the water to the City in adequate volume without pumping, but this is an advantage that also must be shared with both the Delaware River Project and the Lehigh-Pocono Project.

Upper Lehigh River Basin Project

The Upper Lehigh River Basin Project provides for supply of 331 million gallons of water a day to Philadelphia from reservoirs to be constructed on four tributaries of the Upper Lehigh River in the Allegheny Mountain region above Lehigh Gap; a regulating reservoir on Unami Creek in the western portion of Bucks County; and pressure tunnels for collecting the flow from the various reservoirs and delivery by gravity from the regulating reservoir to the existing raw water sedimentation basin at the Roxborough filter plant. Branch conduits for delivery of raw water from Roxborough to the other filter plants would also be required.

The several reservoirs included in the project are:

Tobyhanna Reservoir on the Lehigh River immediately below its confluence with Tobyhanna Creek.

Bear Creek Reservoir on the Lehigh River immediately below its confluence with Bear Creek.

Mud Run Reservoir on Mud Run at a point approximately three-quarters of a mile southeast of Albrightsville.

Pohopoco Reservoir on Pohopoco Creek at a point approximately 1.8 miles above East Weissport.

The impounded waters would flow by gravity from the Tobyhanna Reservoir into Bear Creek Reservoir; the flow line of the Tobyhanna Reservoir being 127 feet higher than that of Bear Creek Reservoir. From Bear Creek and Mud Run Reservoirs, the water would be conveyed by deep pressure tunnel to the Pohopoco Valley where it would rise to the surface and become a gravity conduit discharging into the Pohopoco Reservoir. From Pohopoco Reservoir, a deep pressure tunnel would extend to the Unami Regulating Reservoir, and thence to the City.

It is computed that the developed areas included in this project can be expected to yield 331 million gallons per day and that between 73.5 per cent and 86.1 per cent of the average flows of the streams would be utilized. Even with this high development, the project would not deliver 500 million gallons of water a day, as deemed essential for future needs of the City.

Without any pumping, the Upper Lehigh River Basin Project would furnish the existing filter plants water that is relatively free from pollution and of desirable softness and which could be adequately and satisfactorily purified by normal standard methods of filtration but the volume which could be made available would be insufficient for present needs of the City, and far below estimated future requirements.

Lehigh-Pocono Project

The Lehigh-Pocono Project provides for supply of 500 million gallons of water a day to Philadelphia and involves construction of eight storage reservoirs on tributaries of the Lehigh and Delaware Rivers; a regulating reservoir on Unami Creek in Bucks County; and tunnels for transporting water by gravity from the reservoirs to the existing raw water sedimentation basin at Roxborough.

The project is in the nature of an extension to the Upper Lehigh River Basin Project and provides the additional water required to increase the 331 million gallons daily safe yield of the Lehigh reservoirs to 500 million gallons daily, the volume considered by the Board of Consulting Engineers as necessary for any new water supply for the City.

This objective is attained by supplementing the output of the Tobyhanna, Bear Creek, Mud Run, and Pohopoco Reservoirs of the Upper Lehigh River Basin Project by addition of the Buckwha, McMichaels, Broadheads, and Bushkill Reservoirs of the Upper Delaware River Basin Tributaries Project.

In this combination project, the Buckwha and McMichaels Reservoirs need not be as large as required for the Upper Delaware River Basin Tributaries Project, but with this exception, the eight storage reservoirs and the Unami regulating reservoir would be as previously described.

The reservoirs of the Upper Lehigh would discharge through tunnels from the west into the Buckwha Reservoir and the reservoirs on the Delaware tributaries through tunnels from the east. From the Buckwha Reservoir, a tunnel would carry the combined supply to the Unami regulating reservoir and thence to the Roxborough sedimentation basin at elevation 420 (U.S.G.S. datum).

The Lehigh-Pocono Project has advantages ascribed to the Upper Lehigh River Basin Project, and, in addition, provides a supply of water adequate for estimated full needs of the future. The opportunity is afforded for step development as all the reservoirs of the Pocono region need not be constructed until demands for water should equal the capacity of the reservoirs situated on the Lehigh River and tributaries and those initially constructed on the Pocono watersheds.

In common with all the projects considered, the waters of the Lehigh-Pocono Project will require treatment and filtration and, due to the relatively high color of the component streams, the cost of treatment may be somewhat greater than for waters of the Delaware River Projects.

Tunnels required for this project would be 108 miles in length as compared to 80 miles for the Delaware River Project.

The fact that nine reservoirs are required as compared with two for the Delaware River Project helps to make this one of the most expensive considered.

Preliminary estimates were made of the cost of each of these projects, as follows:

Yardley-Wallpack Bend Project	$152,500,000
Delaware River Yardley Project	$188,730,000
Upper Lehigh River Basin Project (331 m.g.d.)	$240,000,000
Delaware River Project (Wallpack Bend)	$269,400,000

Lehigh-Pocono Project	$376,720,000
Upper Delaware River Basin Tributaries Project	$380,250,000

After the Water Commission had definitely expressed its selection of the Delaware River (Wallpack Bend) site, with the conduits leading to the regulating reservoir at Warrington, instead of utilizing the bed of the river between Wallpack Bend and either Easton or Yardley, a more detailed study was made of this project and the estimated cost of all facilities, including land acquisition and damages and purification facilities, and distribution connections within the City, was $284,588,000.

LOSS OF SANITARY SEWAGE THROUGH STORM WATER OVERFLOWS

By J. E. McKee, Member*

(Presented at a meeting of the Sanitary Section, B.S.C.E., held on March 5, 1947.)

Synopsis

In the design of intercepting sewers and sewage-treatment plants, engineers must determine to what extent storm-water run-off will be intercepted; what proportion of sewage, diluted by storm-water, will escape to protected water courses through sewage regulators and similar overflow devices; and how frequently such overflows will occur. To analyze this problem, a probability study was made of the occurrence of all rainfall, of low as well as high intensities, at Boston, Mass. during the dry-weather months of June through November, based on hourly rainfall statistics for the years 1934 to 1945 inclusive. This investigation revealed that rainfall equal to, or in excess of, 0.01 in. per hr occurred 6.64% of the total time, while precipitation recorded as a trace or more occurred 14.9% of the total time.

Furthermore, a relationship was established to show that storm run-off equal to the dry-weather sanitary discharge is produced by a rainfall intensity of approximately 0.01 in. per hr after impervious surfaces are well wetted. By combining this relationship with the probability of rainfall occurrence, the proportion of sewage that will escape through overflow structures for any given capacity of the interceptors was determined. When twice the average dry-weather flow is intercepted, approximately 2.7% of all domestic sewage may be expected to escape to the receiving stream or 97.3% of all sewage will be intercepted during the months of June through November. By designing the interceptors to take five times the average dry-weather flow, i.e. 0.04 in. per hr of storm water, the percentage of sanitary sewage intercepted can be reduced to 1.2% of all domestic sewage discharge.

The frequency with which overflows occur for various capacities of interceptors was also investigated. When twice the average dry-

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weather flow is intercepted, overflows may be expected about 5 or 6 times per month in the summer. By increasing the capacity of interceptors five-fold, i.e. to ten times the average dry-weather flow, the number of overflows can only be reduced to three per month. This reduction in the number of overflows is hard to justify in view of the small improvement to the stream and the added cost involved.

The concepts developed in this study lead to several practical applications. Primarily they serve as a guide to engineers in the design of interceptors to provide sufficient protection to streams receiving storm-water overflows without requiring excessive capacity from which little improvement results. In addition, they provide public-health authorities and sanitary engineers with a rapid means of estimating pollution of receiving streams following summer storms of long or short duration and of high or low intensity.

* * *

When combined sewers are intercepted for the purpose of conveying sanitary sewage to a treatment plant or to a more advantageous point of disposal, overflow devices or regulators are generally installed in the combined sewer to allow excessive run-off from heavy rainfalls to discharge into the nearest watercourse. Without these overflows, the interceptor would have to be designed with sufficient capacity to carry the peak storm-water run-off. Regulators have the function of diverting the dry-weather flow and a small quantity of storm-water run-off into intercepting sewers, but they cause all discharge in excess of the pre-determined limit to overflow. Economical design of intercepting sewers and sewage-treatment works is dependent upon accurate determination of the peak dry-weather flow and a knowledge of the frequency, magnitude, and effect of storm-water run-off. It is important, therefore, that the two types of flows which govern the selection of the design capacity of the interceptor be determined accurately. Dry-weather flows can be estimated from data pertaining to per-capita sewage flow and ground-water infiltration or they may be determined directly by gaging each outfall sewer. Storm-water run-off, on the other hand, is more difficult to analyze, since low-intensity rainfalls, as well as cloudbursts, produce sewer discharges commonly in excess of the capacity of the interceptors.

In a study of this problem, rainfall data at Boston, Mass. were analyzed to determine: (a) the percentage of time that overflow may be expected to occur for various capacities of the intercepting sewer,

(b) the proportion of sanitary sewage escaping during such overflows and (c) the number of separate and distinct storms that will cause overflows. The study was restricted to the critical six-month period of each year, from June through November. Winter months (Dec., Jan., and Feb.) involve freezing weather when precipitation may result in delayed run-off. Furthermore, low temperatures make the overflow of sanitary sewage less dangerous than during warm summer months. March, April and May, on the other hand, constitute a period of high surface run-off when dilution in the receiving streams minimizes the effect of overflowing sanitary sewage. As stream-flow records indicate, the six months, June through November, have the lowest rate of run-off. To corroborate the discharge statistics, this study revealed that July and August were the months of least-frequent rainfall, with the cooler months having a higher proportion of rainy hours.

Rainfall Probability

Formulae for computing rainfall intensities in Boston and other cities abound in the technical literature. Classic investigations of high-intensity rainfall were made by Meyer (1), Kuichling (2), Sherman (3), and Allen (4), while more recent and rational approaches to the problem were presented by Horner and Jens (5), Hicks (6), Leopold (7), and Horner (8). Although storms of high-intensity rainfall have received much attention, normal or low-intensity rainfalls have aroused much less interest. Yet, as will be shown later, periods of drizzling precipitation are most important in determining the probability of storm-water overflow.

Formulae for high-intensity rainfall commonly take one of the following forms:

$$i = \frac{a}{t + b}$$

$$i = \frac{a}{t^n}$$

$$i = \frac{a}{(t + b)^n}$$

where i = intensity of rainfall in in. per hr during the period, t, in minutes, while a, b, and n are constants determined empirically. Each equation plots as a straight line on logarithmic paper, but the straight-line relationship holds only for high-intensity rainfall or within the limits for which data were analyzed. Extrapolation to low-intensity rainfalls produces erroneous and fantastic results. In each formula, the average rainfall intensity decreases as the duration of the storm increases; but to compute rainfalls of 0.10 in. per hr or less, values of t must be very large, as shown in Table I.

TABLE I.—APPLICATION OF STORM FORMULAE TO LOW-INTENSITY RAINFALL

Equation	City	Author	Value of t, in minutes, corresponding to i = 0.10 in. per hr	i = 0.01 in. per hr
$i = \dfrac{150}{t + 30}$	Boston	Dorr	1470	14,970
$i = \dfrac{20.4}{t^{0.61}}$	Boston	Metcalf & Eddy	6150	268,000
$i = \dfrac{56}{(t + 5)^{0.85}}$	St. Louis	Horner	1720	25,700
$i = \dfrac{K^*}{(t + 7)^{0.7}}$	Boston	Sherman	273**	6,400**

$^*K = 16F^{0.27}$ with F = frequency in years.
**For $F = 0.01$, or rain occurring about every third day.

It is apparent, furthermore, that the frequency and duration of low-intensity rainfall cannot be correlated readily with intensity of such precipitation. Indicated instead is a probability analysis based on past records of hourly precipitation.

For each of its principal stations having recording rain gages, the U. S. Weather Bureau publishes a monthly tabulation showing the precipitation that occurred for each hour of the month. Typical of these data is the tabulation by the Boston office for June, 1945, presented herein as Table II. Hourly records at Boston have been published on the monthly tabulation sheet since October, 1933, although the unpublished record is much longer. These data are based on tipping-bucket rain gages, adjusted for each storm against a standard weighing gage. Hourly statistics were studied for the six-month period, June through November, from 1934 to 1945 inclusive. Probability of rainfall occurrence was determined by counting the number of hours each month during which each intensity occurred. Since rainfall data, like most other natural phenomena, might be expected to

TABLE II—HOURLY RAINFALL AT BOSTON, MASS. FOR MONTH OF JUNE, 1945
BOSTON, MASS. AIRPORT, JUNE, 1945
HOURLY PRECIPITATION

						A.M.				Amount for Hour Ending at								*P.M.*						
Date	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	T	T	.02	.05	.01	.01	T	..	..	..
3	..	..	..	..	.01	.02	.08	.05	.01	.01	.01	..	..	..	..	..	..	...	T	T	T	T	..	T
4	T	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	T	T	T	..
5	T	T	T	T	T	.02	.03	.03	.02	.06	.04	.03	.01	.01	T	.02	T	T	T	T	T	T	T	.01
6	T	T	T	T	..	..	..	..	..	T	T	.01	.02	T	.01	.04	T	.03	.01	..	..	..	..	..
8	...	..	..	..	..	..	..	..	..	..	..	.06	.01	T	.02	T	..	..	..	..	..	..	..	..
9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	T	T	..	..	..
10	..	T	T	..	..	..	..	..	..	..	..	..	..	..	T	T	T	T	.04	.03	.17	.07	.01	.01
11	.03	T	.01	.01	T	T	.01	..	..	..	..	..	..	..	..	..	..	..	.04	T	..	T	.03	T
12	T	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	T	.18	T	T	.06	.02	T	.44	.02
16	.01	..	T	T	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
17	..	..	..	..	.04	.01	..	..	..	..	..	..	..	..	..	..	..	..	T	.09	.03	.06	T	..
19	..	..	..	..	..	..	..	..	..	..	..	..	..	.24	.02	..	..	..	..	..	..	T	T	..
20	..	.10	.61	.11	.28	.97	.10	.05	.02	.03	.06	.06	.01	..	T	T	..	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	T	.01	.06	.06
22	.01	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25	T	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	..	T	.15	.01	..	..	..	T	.01	.05	.18	.03	.07	.09	.15	.31	.11	.05	.04	.05	.04	.04	.04	.01
27	T	T	..	..	..	..	..	..	..	..	..	..	T	..	T	T	T	T	.01	T	T	T	T	T
28	T	..	T	T	.01	T	T	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	T
29	T	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

T indicates trace, too small to measure.

TABLE III—PROBABILITY OF OCCURRENCE OF LOW-INTENSITY RAINFALLS, BY YEARS, DURING THE MONTHS OF JUNE THROUGH NOVEMBER

	Percent of time when rainfall intensity (in. per hr.) was							
Year	.01	.02 or .03	.04 to .07	.08 to .15	.16 to .31	.32 to. 63	Over .64	Sums
1934	2.01%	1.55%	1.53%	0.98%	0.41%	0.05%	0.02%	6.55%
1935	2.30	1.64	0.94	0.78	0.41	0.09	0.02	6.18
1936	1.76	1.73	1.00	0.52	0.64	0.09	0.02	5.76
1937	1.92	1.46	1.44	1.00	0.73	0.23	0.00	6.77
1938	2.26	2.03	2.14	1.48	0.75	0.14	0.14	8.94
1939	1.55	1.23	0.94	0.73	0.43	0.05	0.00	4.93
1940	2.42	1.50	1.48	0.80	0.36	0.09	0.00	6.65
1941	1.78	1.43	1.21	0.93	0.30	0.02	0.02	5.69
1942	1.96	2.16	1.91	0.64	0.48	0.05	0.09	7.29
1943	1.98	1.64	1.27	0.57	0.34	0.11	0.02	5.93
1944	2.09	1.73	1.27	0.73	0.30	0.36	0.09	6.57
1945	2.55	2.30	1.98	0.93	0.48	0.18	0.05	8.47
Means	2.05	1.71	1.43	0.84	0.47	0.12	0.04	6.64

TABLE IV—PROBABILITY OF OCCURRENCE OF LOW-INTENSITY RAINFALLS, BY MONTHS, FOR 1934 TO 1945 INCLUSIVE

	Percent of time when rainfall intensity (in. per hr.) was							
Month	.01	.02 or .03	.04 to .07	.08 to .15	.16 to .31	.32 to. 63	Over .64	Sums
June	2.27%	1.99%	1.69%	1.12%	0.52%	0.14%	0.08%	7.82%
July	1.71	1.15	0.96	0.53	0.43	0.12	0.08	4.98
August	1.39	1.28	1.00	0.55	0.38	0.16	0.03	4.78
Sept.	2.02	1.47	1.26	1.01	0.47	0.13	0.05	6.41
Oct.	1.83	1.40	1.17	0.84	0.49	0.09	0.00	5.81
Nov.	3.09	2.95	2.51	1.02	0.52	0.09	0.00	10.20
Means	2.05	1.71	1.43	0.84	0.47	0.12	0.04	6.64

have a geometrical frequency distribution, groupings were made in a geometric pattern. The number of hours in each grouping (times 100) divided by the total hours in a month gave the percentage of time during which rainfall of that group intensity occurred. Results of these computations are presented in Table III by years and Table IV for each month. Figure I is a plot on one edge of logarithmic

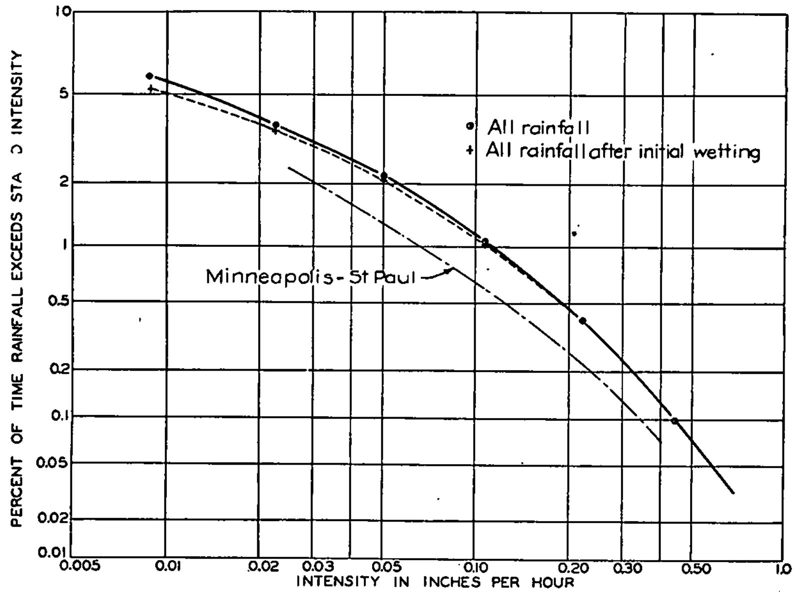

FIG. I PROBABILITY OF OCCURENCE OF RAINFALLS OF VARIOUS INTENSITIES
(BASED ON RAINFALL RECORD FOR BOSTON 1934 TO 1945)

TABLE V—GEOMETRICAL CENTER-OF-STRIP CALCULATIONS TO ACCOMPANY FIG. 1.

Row	Recorded Rainfall (1)	Range (2)	Geom. Mean Mg (3)	Occurrence for Range in % (4)	% Greater than Mg* (5)
a	.01	.005 to .015	.00865	2.04	5.62
b	.02 or .03	.015 to .035	.0229	1.70	3.75
c	.04 to .07	.035 to .075	.0512	1.43	2.18
d	.08 to .15	.075 to .155	.108	0.84	1.05
e	.16 to .31	.155 to .315	.221	0.47	0.40
f	.32 to .63	.315 to .635	.447	0.12	0.10
g	over .64	.635 to ∞	——	0.04	0.02

*E.g., for row c: (Col. 5) = Sum of rows d, e, f, and g (Col. 4) plus ½ row c (Col. 4) = .04 + .12 + .47 + .84 + ½ (1.43) = 2.18%.

probability paper showing how often a given intensity of rainfall will be equalled or exceeded. Center-of-strip plotting was employed, with the geometric mean between group extremes taken as the center point. Data and computations for this plot are given in Table V.

From Fig. I it is evident that rainfall at Boston during the summer and autumn months may be expected to equal or exceed 0.01 in. per hr approximately 6% of the time, while rainfall of 0.10 in. per hr or greater occurs only about 1% of the time. A similar analysis for each month (see Table IV) reveals that August is the month of least-frequent rainfall, with 0.01 in. per hr being equalled or exceeded only 4.78% of the time. For the six-month span considered in this study, November has the most numerous hours of rainfall with 0.01 in. per hr (or more) occurring 10.2% of the time. If the foregoing figures had included each hour for which a trace of rainfall had been recorded (note frequency of T, for trace, in Table II) it would have been shown that precipitation of a trace or more occurred 14.9% of the time during the period of this study. Or expressed in common parlance, it rains about one-sixth of the time in the summer and autumn in Boston.

Inasmuch as hydrological data are known to fluctuate widely from year to year, the reliability of the results for this 12-year study was investigated. From Table III it is to be noted that the sums of the percentage of hours of rainfall of 0.01 in. per hr or more vary from a low value of 4.93% in 1939 to a high figure of 8.94% in 1938, with the arithmetic mean of the sums being 6.64%. For these 12 sums, the standard deviation is 1.15% and the standard deviation of the mean is 0.34%. Thus, we might expect the true mean to be somewhere between $6.64 + 0.34 = 6.98\%$ and $6.64 - 0.34 = 6.30\%$. Since frequency rather than magnitude is under consideration, the Bernoullian sigma is more applicable. For the six-month period of each year, comprising $30.5 \times 6 \times 24 = 4392$ hours, the value of $\delta_B = 0.38\%$ and for the 12-year span, $\delta_B = 0.11\%$. Based on the Bernoullian sigma, therefore, the true mean should be between 6.75% and 6.53%. These values, in turn, might be subject to long-range trends or cycles in the phenomenon of precipitation. For purposes of this study, which is predicated upon a series of approximations, the parameters based on 12 years of data appear to be reliable.

RUN-OFF FROM LOW-INTENSITY RAINFALL

Having analyzed the probability of occurrence of rainfalls of various intensities, let us next consider what proportion of rainfall will appear as surface run-off, thus increasing the normal dry-weather discharge from combined sewers. Horner (8) has shown that surface run-off is retarded and decreased by: (a) retention on vegetation, (b) infiltration into the soil, (c) wetting of impervious surfaces, (d) depression storage, and (e) surface detention required to build up a film of water sufficiently thick to cause flow. All of these factors are commonly combined into estimated "coefficients of run-off" which, in turn, depend to a large extent upon the "relative imperviousness" of an area, i.e. the ratio of impervious surfaces to the total area, as well as upon the duration and intensity of rainfall. Kuichling (2) presented the "relative imperviousness" of various types of surfaces when dry and on low slopes. He considered densely built-up sections of a city to have a "relative imperviousness" varying from 70 to 90% while sparsely settled residential areas were taken as 10 to 30% impervious.

From the factors given by Horner, it is obvious that the coefficient of run-off will increase with the duration of a rainfall as impervious surfaces become fully wetted, depressions are filled, semi-pervious soil becomes saturated, and a flowing film of water is established. Careful evaluations of these changes in the coefficient of run-off have been made by many observers for high-intensity rainfalls, but the applicability of the results to low-intensity rainfalls is doubtful. For heavy precipitation, lasting over three hours, the coefficient of run-off tends to approach 1.00; but for drizzling rain, the coefficient may increase but slowly with time.

In the absence of precise data for run-off from low-intensity rainfall, a few logical assumptions were necessary in order to carry out this study. For such storms, only the rain that falls upon impervious surfaces was assumed to run off into storm drains; or expressed otherwise, all precipitation upon vegetation and unpaved surfaces was considered to be evaporated, transpired, or to become ground water. The logic of this assumption may be questioned by many engineers inasmuch as storms of high intensity or prolonged duration can be expected to produce surface run-off from open country. However, for rainfalls of low intensity during the six "dry" months when the soil and vegetation are receptive, it seems logical that little, if any, run-off from pervious surfaces would occur. Rainfalls of 0.20 in. per hr or more constitute only 10% of the total hours of rainfall whereas 90% of all hours of rainfall have less than 0.20 in. per hr. A further justification for this assumption lies in the fact that it is counterbalanced more or less by the following assumption pertaining to impervious areas.

After the initial wetting of surfaces, including depression storage, all rain falling upon impervious surfaces was assumed to run off; that is to say, for well-wetted impervious surfaces the coefficient of run-off becomes equal to 1.00. Hicks (6), however, evaluates the impervious surface loss as 10% of the rainfall. Since some of the precipitation upon impervious roofs and sidewalks runs off onto pervious areas and absorptive soil, this latter assumption tends to balance the previous one pertaining to pervious surfaces.

How much rainfall, then, is needed to wet impervious surfaces, fill minor depressions and start run-off? Quite obviously, the quantity is not fixed, but varies according to the slope, roughness, heat, and degree of previous wetting. A comparison of miscellaneous data gleaned from the literature leads to the conclusion that the amount of rainfall needed to effect run-off from impervious surfaces is not very great, probably not in excess of 0.03 in. Hicks (6) presented curves showing that the depth of "composite storage", including depression storage and depth of run-off, for the recession side of several run-off hydrographs was in the vicinity of 0.02 or 0.03 in. when run-off ceased. He estimated, furthermore, that 10% of the rainfall upon impervious surfaces would be lost. This figure bears out the contention that, for low-intensity rainfalls, less than 0.03 in. is required to start run-off.

Allowing 0.03 in. for surface wetting, the rainfall probability study presented in the first portion of this article was re-examined. The first 0.03 in. of each period of rainfall was eliminated (with a trace, T, being considered as 0.0025 in.) and probabilities of occurrence were recomputed. The results of the revised analysis are shown by the dotted line on Fig. I, and are presented in Tables VI and VII which are comparable to Tables III and IV respectively. For a recorded rainfall of 0.01 in. per hr, or more, allowance for surface wetting reduced all rainfall occurrence from 6.64% to 5.65% of the total time; but for rainfall in excess of 0.08 in. per hr, the probability was changed only from 1.47% to 1.41% of the total time. Since low-intensity rainfalls occur most frequently and are thus most significant in determining the amount of overflow of sanitary sewage, this effect of surface wetting could not be neglected. In the following analyses, therefore, Tables VI and VII have been used in lieu of Tables III and IV.

TABLE VI—RAINFALL PROBABILITY, BY YEARS,
WITH THE FIRST 0.03 INCHES OF EACH STORM BEING ELIMINATED

	Percent of time when rainfall intensity (in. per hr.) was							
Year	.01	.02 or .03	.04 to .07	.08 to .15	.16 to .31	.32 to. 63	Over .64	Sums
1934	1.44%	1.35%	1.32%	0.91%	0.41%	0.05%	0.02%	5.50%
1935	1.73	1.28	0.84	0.75	0.41	0.09	0.02	5.12
1936	1.21	1.37	0.89	0.50	0.64	0.09	0.02	4.72
1937	1.25	1.30	1.25	0.96	0.73	0.23	0.00	5.71
1938	1.87	1.60	2.10	1.44	0.75	0.14	0.14	8.04
1939	1.21	0.94	0.98	0.57	0.43	0.05	0.00	4.18
1940	1.50	1.14	1.39	0.71	0.36	0.09	0.00	5.19
1941	1.12	1.36	0.98	0.93	0.30	0.02	0.02	4.73
1942	1.32	2.05	1.73	0.64	0.48	0.05	0.09	6.36
1943	1.52	1.25	1.18	0.50	0.34	0.11	0.02	4.92
1944	1.73	1.59	1.16	0.68	0.30	0.36	0.09	5.91
1945	2.32	1.87	1.82	0.84	0.48	0.18	0.05	7.56
Means	1.52	1.42	1.30	0.78	0.47	0.12	0.04	5.65

TABLE VII—RAINFALL PROBABILITY, BY MONTHS,
WITH THE FIRST 0.03 INCHES OF EACH RAINFALL BEING ELIMINATED
(1934 TO 1945, INCL.)

	Percent of time when rainfall intensity (in. per hr.) was							
Month	.01	.02 or .03	.04 to .07	.08 to .15	.16 to .31	.32 to. 63	Over .64	Sums
June	1.74%	1.74%	1.60%	1.03%	0.52%	0.14%	0.08%	6.85%
July	1.18	0.91	0.75	0.47	0.43	0.12	0.08	3.93
Aug.	0.84	1.02	0.91	0.56	0.38	0.16	0.03	3.86
Sept.	1.57	1.26	1.11	0.95	0.47	0.13	0.05	5.55
Oct.	1.20	1.13	1.05	0.77	0.49	0.09	0.00	4.74
Nov.	2.63	2.52	2.43	0.99	0.52	0.09	0.00	9.19
Means	1.52	1.42	1.31	0.78	0.47	0.12	0.04	5.65

Relation Between Dry-Weather Sanitary Flow and the Run-Off from Low-Intensity Rainfall

Intercepting sewers are generally designed to carry two to four times the average dry-weather flow, the design being dictated by fluctuations and peaks of the dry-weather discharge and by the importance of excluding raw sewage from the stream receiving the overflow. Within any city or in any general locality, intercepting sewers and overflow structures cannot be designed by any general rule inasmuch as peak dry-weather flows vary with the size and characteristics of the area served. The author made a survey of several typical drainage areas in New England cities which revealed that peaks in dry-weather sanitary flow combined with ground-water infiltration range from 160% of the average discharge for a large area of over 60,000 people to 250% for a typical small area of about 50 acres and 1,000 persons. Thus, the common practice of intercepting two or three times the dry-weather flow constitutes sound engineering judgment insofar as peaks in the normal flow of sanitary sewage are concerned. But what if a long drizzling rain is superimposed upon the average domestic discharge? How many inches of surface run-off will be intercepted if the trunk sewer has been designed to take no more than the peak dry-weather flow?

The capacity of an interceptor for storm-water run-off depends on the quantity of sanitary sewage being discharged at the time the storm occurs. Surface run-off coinciding with the peak sanitary design flow for the interceptor will cause overflows to occur with the first trace of rainfall reaching the sewer. On the other hand, if precipitation occurs at night or early morning when the flow of sanitary sewage is small, the interceptor will have capacity for more storm water. Inasmuch as Boston rainfall data, similar to those shown in Table II, reveal no tendency to favor certain hours of the day (contentions of commuters to the contrary notwithstanding) the probability of surface run-off coinciding with peak sanitary discharge is balanced by the probability of rainfall during periods of low sanitary flow. Hence over a long period of time, the capacity of the system for surface run-off should be based upon the mean dry-weather sanitary flow. If the interceptor is designed to take an average of twice the dry-weather flow, then in the long run a quantity of storm run-off equal to the dry-weather flow will be intercepted during periods of rainfall. The problem then is resolved into establishing a relationship between dry-weather sewage flow and rainfall intensity.

Fortunately for purposes of this study, it may be shown that a relationship exists between the average dry-weather flow for a given area and low-intensity rainfall on the same area; viz., that storm run-off equal to the dry-weather sanitary discharge is produced by a rainfall intensity of approximately 0.01 in. per hr. The value of this relationship is verified in the following discussion.

The so-called "rational method" for computing storm-water run-off uses the formula:

$$Q_r = c\,i\,A \tag{1}$$

where Q_r is the run-off in cfs, c is the coefficient of run-off, i is the rainfall intensity in in. per hr (approximately equal to cfs per acre), and A is the tributary area in acres. The average dry-weather flow, on the other hand, may be expressed as:

$$Q_d = g\,A + p\,s\,A \tag{2}$$

where Q_d is the average dry-weather sanitary discharge in gpd, A is the tributary area, g is the rate of ground-water infiltration in gpd per acre, p is the population density per acre, and s is the per-capita sewage flow in gpd.

To determine at what intensity of rainfall the run-off becomes equal to the dry-weather sanitary flow, equations (1) and (2) have been combined, with due allowance for conversion between cfs and mgd. Then

$$646{,}000\ Q_r = Q_d$$
$$646{,}000\ ci\,A = g\,A + ps\,A$$

Cancelling out the area, A, and solving for i,

$$i = \frac{g + p\,s}{646{,}000\ c} \tag{3}$$

By means of sewer gagings and detailed studies of population densities and imperviousness, values of g, p, s, and c can be established for any sewer outfall. To generalize for a city having many intercepted outfalls, the value of s (per-capita sewage flow) must be considered to be uniform throughout the city. Ground-water infiltration, however, is apt to vary widely, depending on the age, type, and proximity of sewers, surrounding soil, and overlying impervious surfaces. In general, values of g range from 500 to 1500 gpd per acre in New England.

In the preceding equation (3), therefore, it becomes apparent that i varies primarily with the values of g, p, and c. For drainage areas having dense population and old sewers, values of c are correspondingly high; while for new suburban developments, g, p, and c are all low. That these values tend to compensate each other will be shown by a few typical examples. In all cases, sewage flow is taken as 70 gpd per capita.

Case I—a densely populated area (60 persons per acre), old brick sewers ($g = 1000$ gpd per acre) and highly impervious ($c = .80$). Then by equation (3)

$$i = \frac{g + p\,s}{646{,}000\,c} = \frac{1000 + 60 \times 70}{646{,}000 \times 0.80} = 0.0101 \text{ in. per hr}$$

Case II—a normal residential area (20 persons per acre), well-built but old sewers, ($g = 800$ gpd per acre) and $c = 0.30$; then

$$i = \frac{g + p\,s}{646{,}000\,c} = \frac{800 + 20 \times 70}{646{,}000 \times 0.30} = 0.0114 \text{ in. per hr.}$$

Case III—a thinly populated suburb with 5 persons per acre, new sewers ($g = 600$ gpd per acre) and $c = 0.15$; then

$$i = \frac{g + p\,s}{646{,}000\,c} = \frac{600 + 5 \times 70}{646{,}000 \times 0.15} = 0.0098 \text{ in. per hr}$$

In another example, Case II might be considered for a newer city with tight sewers ($g = 500$ gpd per acre) and with lower water use and sewage flow ($s = 50$ gpd per captita); then

$$i = \frac{500 + 20 \times 50}{646{,}000 \times 0.30} = 0.0077 \text{ in. per hr}$$

Many other examples were studied, but as long as the values used were logical and typical of New England experience, the value of i required to produce run-off equal to the average dry-weather sanitary flow was always found to be in the general magnitude of 0.01 in. per hr. To be sure, the values may have differed by 50% or more on either side of 0.01 in. per hr but for the geometrically distributed rainfall magnitudes considered, these differences were insignificant.

The Duration and Extent of Sewage Overflows

With the relationship established to show that a rainfall intensity of 0.01 in. per hr causes run-off approximately equal to the dry-weather flow in sewers, an analysis was made to determine the proportion of domestic sewage that escapes through overflow devices when the interceptors carry twice the average dry-weather flow. For a storm of intensity "i" superimposed upon the average sanitary discharge (equal to 0.01 in. per hr) the proportion of sewage escaping (E) to the receiving stream is given by the relationship:

$$E = \frac{i - .01}{i + .01}$$

where the denominator, i + .01 is related to the total flow in the sewer and the numerator, i — .01 is related to the quantity of mixed run-off and sewage that overflows. The difference between numerator and denominator represents the quantity intercepted and equals 0.02 in. per hr or twice the average dry-weather sanitary discharge. For example, during a rainfall intensity of 0.12 in. per hr.

$$E = \frac{.12 - .01}{.12 + .01} = \frac{.11}{.13} = 0.846$$

or 84.6% of the sewage will escape to the stream.

If the interceptor will carry three times the dry-weather flow, equation (4) becomes

$$E = \frac{i - .02}{i + .01}$$

or for the interception of $(r + 1)$ times the dry-weather flow,

$$E = \frac{i - r}{i + .01}$$

These relationships have been extended to higher rainfall intensities and the data derived are presented graphically in Fig. II. For any given capacity of the intercepting sewer and for a known rainfall intensity, the relative amount of sewage lost to the stream during the storm can be read directly from the plot.

From Fig. II it can be seen that if interceptors are designed for twice the dry-weather flow, 50% of the sewage will overflow during

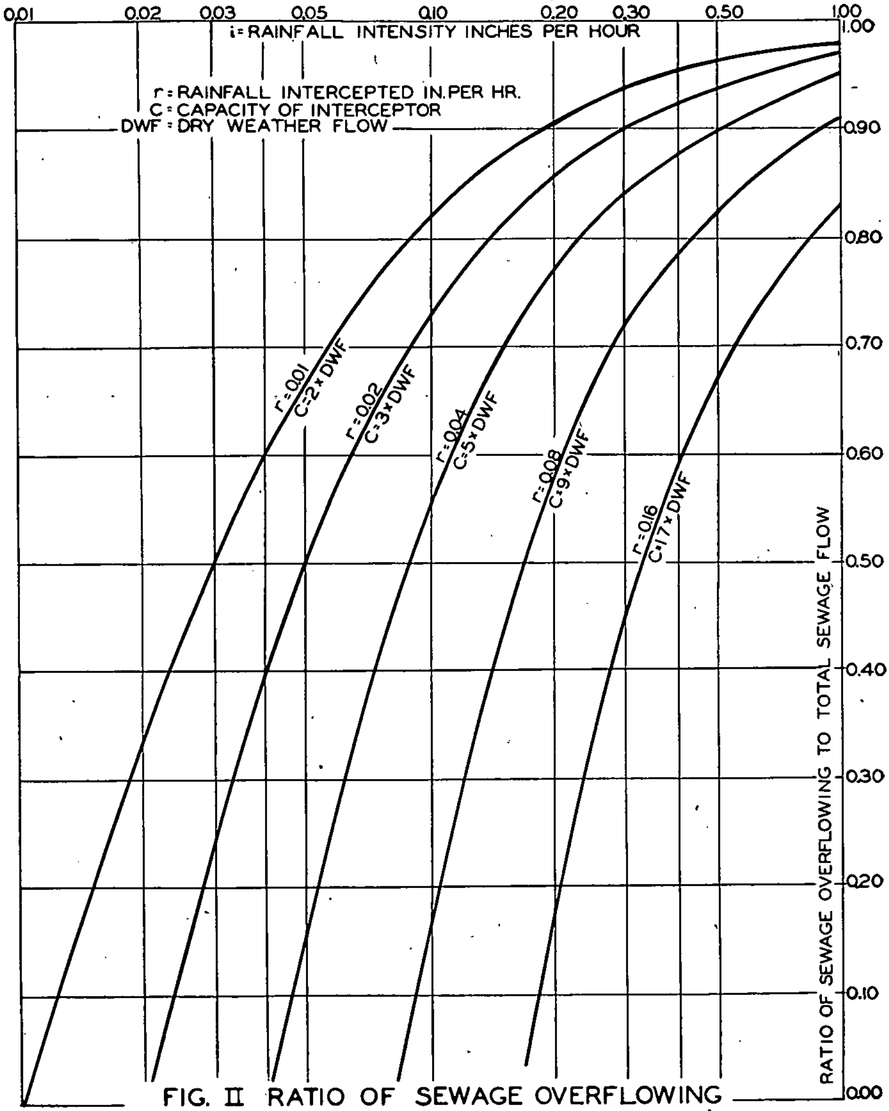

FIG. II RATIO OF SEWAGE OVERFLOWING AT VARIOUS RATES OF INTERCEPTION $E = \frac{i - r}{i + 0.01}$

a prolonged storm having an intensity of 0.03 in. per hr. If the interceptors are made very large so as to take, for example, nine times the dry-weather flow, all of the sewage and storm-water run-off will be intercepted up to a rainfall intensity of about 0.08 per hr; 17% of the mixture will overflow at a rainfall intensity of 0.10 in. per hr; and 82% at a rainfall intensity of 0.50 in. per hr. It is pertinent to note from Fig. I that an intensity of 0.08 in. per hr is equalled or exceeded about 1.25% of the time during the June to November period. This means that even with interceptors designed to carry nine times the average dry-weather discharge, overflow of sewage may be expected for 55 hours during the 6-month period. As will be shown hereinafter, these 55 hours occur not as a few prolonged storms, but as 15 to 20 periods of overflow with an average duration of 3 to 4 hours. This fact is highly significant in selecting the economical capacity of large intercepting sewers.

From the above examples it is also significant to note that with a rainfall intensity of only 0.10 in. per hr, 82% of the bacteria in the raw sewage will overflow to the receiving stream if the interceptors carry twice the dry-weather flow and 17% even with interceptors large enough to accommodate nine times the dry-weather flow. Thus with a comparatively light rainfall, gross bacterial pollution of the stream will take place even with very large interceptors.

For long periods of time, i.e., for an entire summer or for summer months in general, the proportion of all sewage that reaches the receiving stream is a function of (a) the probability of occurrence of each rainfall intensity and (b) the proportion of sewage escaping at that intensity. The sum of the products of these two functions represents the total proportion of all sewage that may be expected to overflow. For the months from June through November and the rainfall probabilities presented hereinbefore, Fig. III shows the product of these factors for each intensity. For example, rainfall of between 0.035 and 0.075 in. per hr may be expected to occur 1.31% of the time; during such rainfalls, 67.4% of the sewage will overflow. Hence 1.31% × 67.4% = 0.88% of all sewage may be expected to escape as a result of precipitation recorded as 0.04 to 0.07 in. per hr. The area under Curve C in Fig. III represents the total overflow of sewage. It is approximately equal to the sums of the products of the points in Curves A and B, or 2.68% of the total sewage flow.

Similar analyses separated by months are summarized in Table

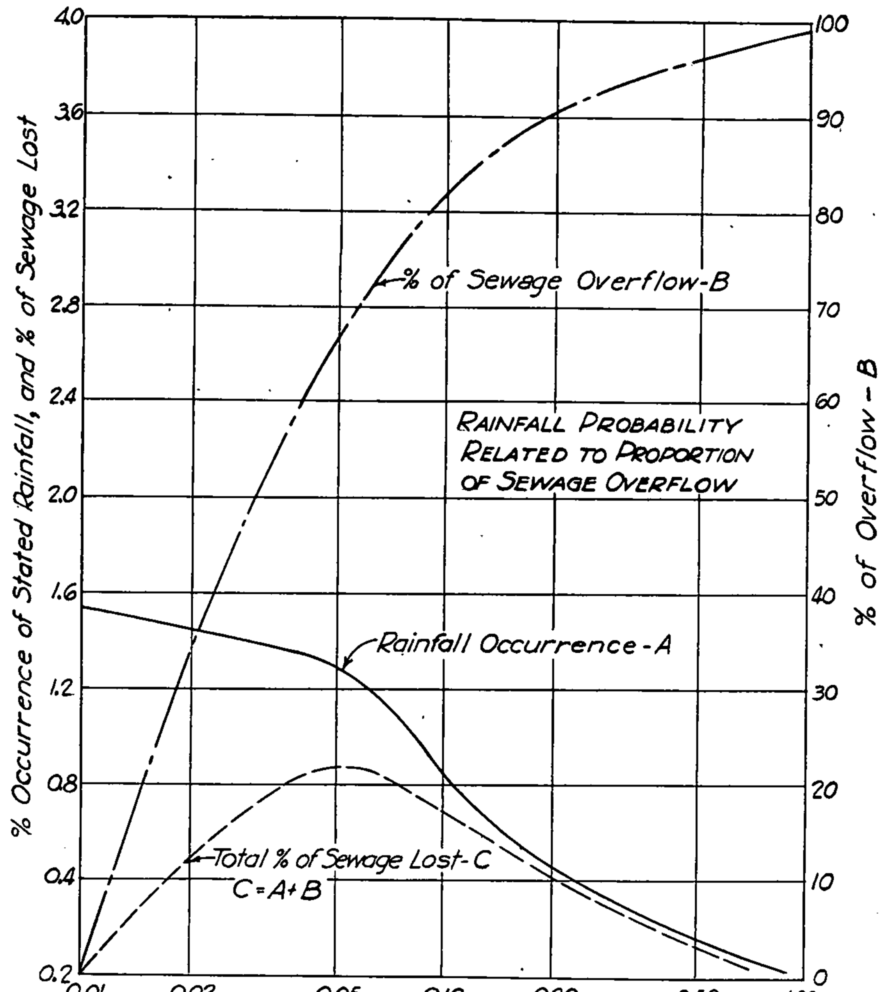

Fig. III, Rainfall Intensity— in. per hr.

VIII and shown graphically by Fig. IV. For other rates of interception, e.g., for three or more times the dry-weather flow, Fig. V shows the proportion of total sewage that may be expected to overflow. Thus, the interception of four times the dry-weather flow will result in the escape of about 1.5% of all sanitary sewage during

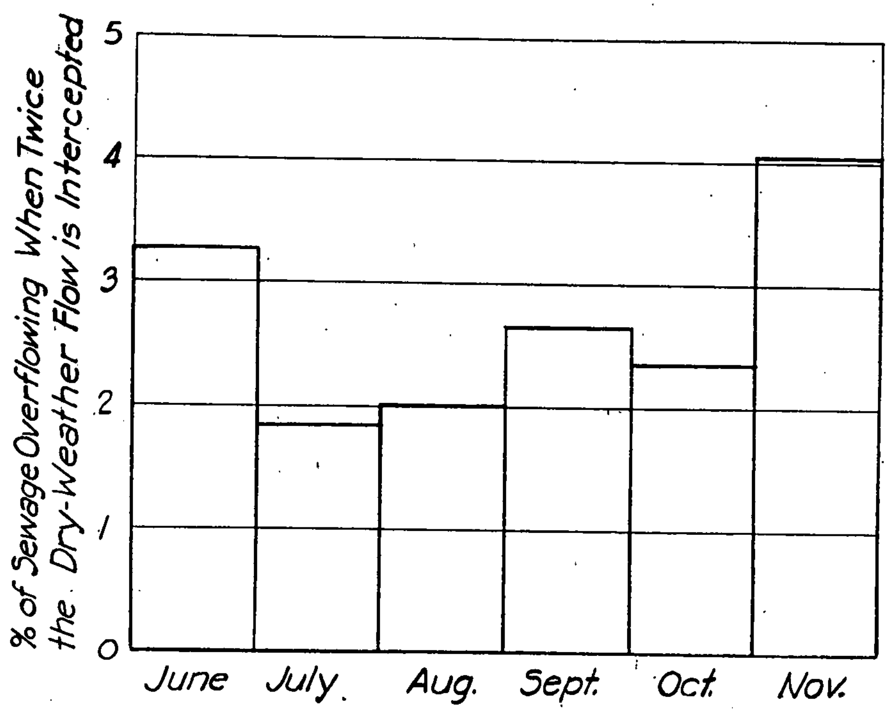

FIG. IV, SEWAGE OVERFLOW BY MONTHS

the six-month period and the interception of six times the dry-weather flow will cause a loss of about 1.0% of all sanitary sewage.

From Table VIII and Fig. V it is evident that the total amount of sewage which will overflow into the stream is relatively small, even with interceptors designed to take only the peak dry-weather flow of sewage and ground water. It is further evident that the improvement obtained with large interceptors is of questionable value. For example, if the capacity of the interceptors is increased five-fold so as to accommodate 10 times the average dry-weather flow, the amount of sewage overflowing will be reduced from 2.7% to 0.6%; but the percentage of sewage intercepted will be increased only from 97.3% to 99.4%. In other words, the hydraulic capacity of all interceptors and treatment works would be increased 500% to handle only 2.1% more sanitary sewage.

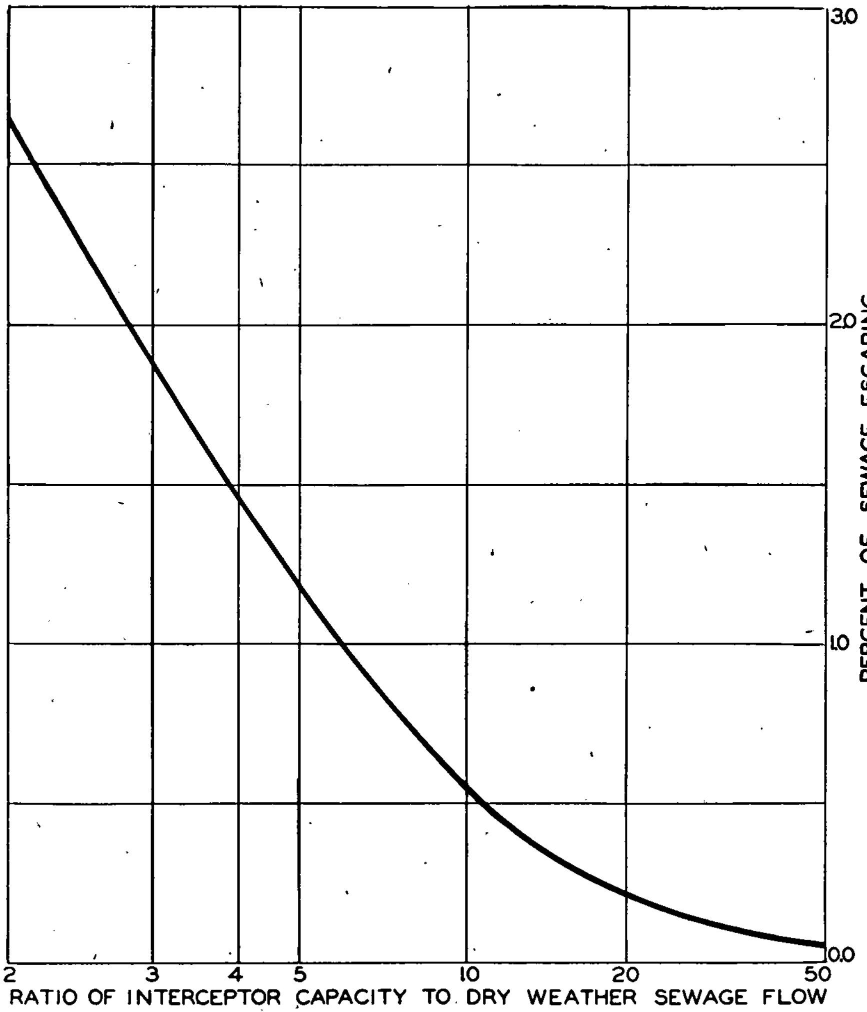

FIG. V PERCENT OF TOTAL SEWAGE OVERFLOWING

(JUNE TO NOVEMBER INCLUSIVE)

FOR VARIOUS RATES OF INTERCEPTION

TABLE VIII—PROPORTION OF SEWAGE OVERFLOWING WHEN TWICE THE DRY-WEATHER FLOW IS INTERCEPTED.
(DATA FOR BOSTON, 1934-1935)

Month	% of time of rainfall equals or exceeds 0.01 in. per hr.	% of total sewage lost through overflow
June	7.82%	3.29%
July	4.98	1.84
August	4.78	2.00
September	6.41	2.63
October	5.81	2.33
November	10.20	4.02
Means	6.64	2.68

FREQUENCY OF SEWAGE OVERFLOWS

The foregoing analysis has shown the total number of hours during the critical six-month period when overflow will probably occur and the percentage of sewage that may be expected to escape for various rates of interception; but the number of storms involved was not determined. To estimate the frequency with which overflow may be expected to occur for various capacities of interceptors, a further statistical study of Boston rainfall records has been made. In this analysis, the records were examined to find the number of storms per month in which various low-intensity rainfalls were equalled or exceeded. No storms were counted unless (a) the total rainfalls exceeded 0.04 inches, of which 0.03 inches was allowed for wetting and the first 0.01 in. per hr thereafter was assumed to be intercepted; and (b) the storm was followed by at least 24 hours during which no overflow occurred. In other words, two periods of overflow within 24 hours of each other were considered as one storm and rated at the maximum intensity. Since the previous study had shown little statistically significant difference in results between the 12-year record and a shorter 5-year record, the Boston rainfall data for 1941 to 1945 were used, and the study was limited to the bathing months of June through September. The results of the analysis are presented in Fig. VI in terms of the number of overflows which may be expected per month for various capacities of interceptors.

The peak dry-weather flow in most large combined sewers ranges, in general, from about 1.5 to 3 times the average dry-weather flow.

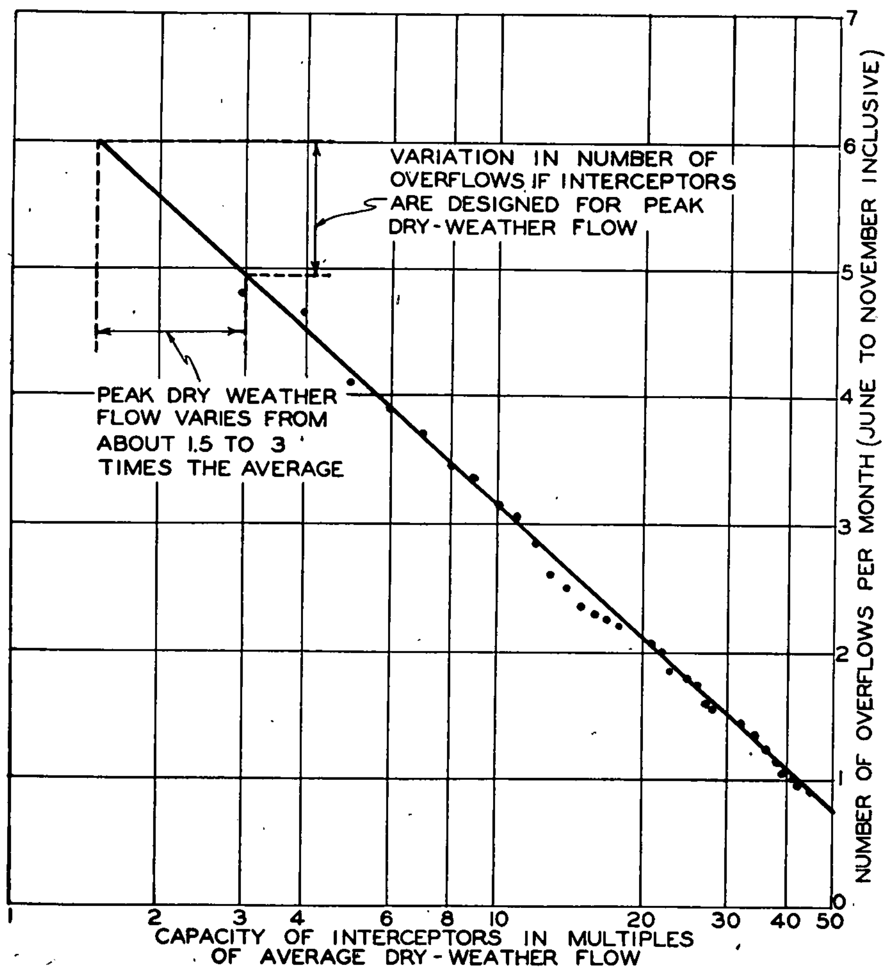

FIG. VI EFFECT OF INTERCEPTOR CAPACITY ON FREQUENCY OF OVERFLOW OF SANITARY SEWAGE

Fig. VI indicates that if interceptors are designed to carry the peak dry-weather flow, sanitary sewage mixed with storm-water may be expected to overflow about 5 or 6 times per month. On the other hand, if interceptors are designed large enough to accept, for example, ten times the average dry-weather flow, the number of overflows will be reduced but there will still be about 3 overflows per month. Thus by increasing the capacity of the interceptors approximately five-fold, the number of overflows per month is only halved. The added cost of the larger interceptors does not appear to be justified by the reduction in the number of times sewage will escape to the stream.

SIGNIFICANCE

The concepts presented in this study lead to several interpretations and practical applications. By similar probability studies of rainfall data in each region of the U. S., engineers can determine what rate of storm-water interception provides the best balance between economy of design and abatement of stream pollution. The frequency and extent to which sewage is allowed to escape to a receiving stream will be dictated by the uses to which that stream is put at various seasons of the year. Where water supplies or shellfish beds must be protected, the added costs of high-capacity interceptors may be justified, but where oxygen depletion is the sole criterion, interception of the peak dry-weather flow would appear to be sufficient. Where more than the peak dry-weather flow is to be intercepted and treated, the engineer should be able to justify the added cost for the sewer and treatment plant by a comparison with other means of achieving the same results. In many cases storm-water detention tanks, chlorination of overflows, or the installation of separate lateral sewers may be economically more feasible. One method of preventing any bacterial contamination of the stream whatsoever is to design interceptors to carry the peak storm run-offs, i.e. to make combined sewers of the interceptors. This solution will generally prove to be very costly. Where the sewage is to be treated, the overflows problem is merely transferred to the treatment plant site. A second method would be to provide storm-water holding tanks as was done at Columbus, Ohio, with accumulated storm-water being released to the interceptor gradually after the storm has passed. At Columbus, Ohio, Gregory, Simpson, Bonney and Allton (9) pointed out that new sewers and interceptors were designed on a basis of overflow not more than four times a year in the central part of the city or more than eight times a year in outlying districts. To reduce the frequency of storm-water overflow to these design requirements without overloading the treatment plant, "storm standby tanks" were installed. These tanks intercept excessive storm water, mixed with sanitary sewage, and discharge the accumulation to the treatment plant gradually following abatement of the storm. A third possible palliative would be to chlorinate all overflows, but even then it is doubtful if more than a 90% bacterial kill could be achieved because of the short contact time that would be available. The fourth and most practical means for the elimination of bacterial pollution resulting from summer storm-water overflows is to separate the sanitary sewers from the storm drains. This principle is generally recognized and put into effect for new systems although some engineers persist in their preference for combined sewers.

At Minneapolis and St. Paul (10) the Metropolitan Drainage Commission determined that 0.04 in. per hr of rainfall should be removed by interceptors. Correspondingly, they estimated that overflow would occur 1.7% of the total time and that 1.1% of the total annual sewage would be discharged to the river. With reference again to Fig. I, it may be seen that Boston rainfall data indicate overflow occurring 2.2% of the time when interceptors take 0.04 in. per hr and Fig. V shows the corresponding loss of sewage to be 1.2%. These data, for two cities having strikingly different climatic conditions, show remarkably close similarity. At Minneapolis and St. Paul, increasing the capacity of interceptors to carry double the amount of storm water, i.e., 0.08 in. per hr, would have decreased the proportion of sewage lost from 1.1% to 0.6% (at Boston from 1.2% to 0.6%), but the cost of interceptors would have been increased 38%.

Conversely, for a system of interceptors already installed, it is possible to compute to what extent the receiving stream will be polluted by overflowing sewage during each month of the year. When interceptors in the Boston area are designed to take the peak dry-weather flow (or about 0.01 in. per hr of rainfall superimposed upon the average dry-weather flow), Fig. IV shows that approximately 2% of all sewage will reach the supposedly protected water-courses during the critical recreational months of July and August and Fig. VI shows that overflows will occur 5 or 6 times each month.

Another application relates to a lake or long river backwater into which several municipalities discharge treated sewage. If a city of

100,000 population has interceptors and regulators that allow 3% of all sewage to escape untreated, a smaller town of perhaps 5,000 persons nearby should not be required to institute complete treatment of sewage when primary treatment alone would produce an effluent causing much less total organic pollution than the escaping raw sewage of the large city. Rainfall and overflow studies thus serve as a guide to state and federal public-health authorities in prescribing degrees of treatment.

Still another application, and one that calls for detailed data and charts, relates to the health officer or sanitary engineer who must approve or certify water supplies, bathing beaches, and shell-fish areas. By means of a few sewer gagings, and studies of drainage areas, data may be accumulated to show precisely what proportion of sewage will overflow at each intercepted outfall sewer, at each hour of the day. These figures could be assembled into composite curves somewhat similar to those in Fig. II. Following a summer rainstorm, for which the local office of the Weather Bureau could report average intensity immediately, the health officer or sanitary engineer could consult the charts and determine readily to what extent the receiving streams had been polluted by overflows. Orders could be issued immediately to restrict shell-fish taking and warnings could be sent to waterworks operators to increase chlorine dosages. In contrast, results of bacteriological tests of river water would not be known for 24 to 48 hours, too late to be of practical use.

Acknowledgements

The problem upon which this study was based was posed originally by Thomas R. Camp, in connection with the investigations being conducted by the Merrimack River Valley Sewerage District under the direction of Thomas A. Berrigan, Chairman. Both Mr. Camp and Mr. Berrigan provided helpful suggestions and constructive criticism while the study was in progress. The writer is also indebted to Dean Gordon M. Fair of Harvard University for guidance and references, particularly in connection with the Columbus and Minneapolis-St. Paul comparisons. Last but not least, the Weather Bureau deserves commendation for providing the hourly rainfall statistics upon which this entire study was based.

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LOSS OF SANITARY SEWAGE THROUGH STORMWATER OVERFLOWS

By William E. Stanley, Member*

(A discussion of Paper by J. E. McKee at meeting of Sanitary Section, B.S.C.E., held on March 5, 1947.)

The unique title of Dr. McKee's paper is intriguing; his brilliant mathematical analysis of the Boston twelve year record of hourly rainfall intensity data is extremely interesting; and his several hypotheses used to transform rainfall intensity data into estimates of sewage flow rates and possible overflow frequencies and magnitudes are encouraging efforts to provide a basis for the solution of a problem which has long troubled the minds of engineers charged with the capacity design of intercepting sewers.

Studies some years ago of rainfall intensities over .01 inches per hour at Chicago and at Minneapolis gave the following comparative data:

Chicago Data (See Fig. A)			Minneapolis Data		
Year	Rainfall Time Percentage of Total Time During Year		Year	Rainfall Time Percentage of Total Time During Year	
1920	5.46		1915	7.36	
1921	5.20		1918	6.88	
1922	5.20		1921	6.17	
1923	5.82		1924	7.10	
1924	4.62		1927	8.48	
5 year Average		5.27	5 year Average		7.20

These data may be summarily compared with Dr. McKee's data as follows:

*Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Place	Rainfall Time per cent of Total Time Average For Study Period	 Minimum Yearly Average	 Maximum Yearly Average
	%	%	%
Boston	6.64*	4.93*	8.94*
Chicago	5.27	4.62	5.82
Minneapolis	7.20	6.17	8.48

*6 summer and fall months.

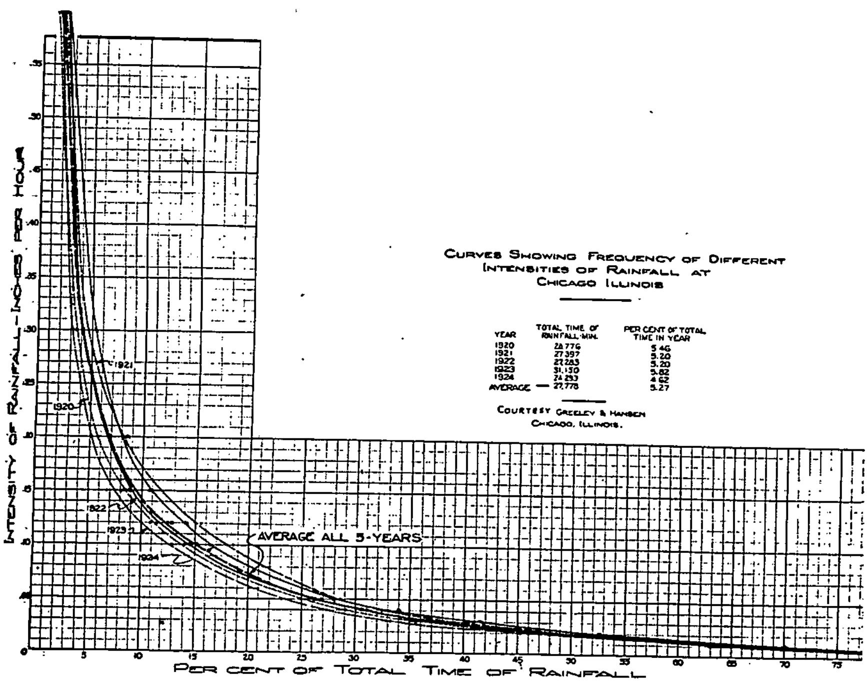


FIGURE A

If the other six months of the year, including winter and spring rains, had been included in the analysis of the Boston data, the yearly average percentages undoubtedly would have been higher.

Thus, the differences in the figures for the percentage of total time during which rainfalls over .01 inches per hour have occurred in Boston, Chicago and Minneapolis, are much less significant than the unknown factors which determine the increase in rates of sewage flows resulting from low-intensity rainfalls.

Rainfall intensities equal to or greater than 0.04 inches per hour have occurred at Boston, Chicago and Minneapolis as follows:

Place	Per Cent of Total Time	Remarks
Boston	2.2	Dr. McKee's Fig. I
Chicago	1.6	1920 to 1924, incl.
Minneapolis	1.7	1915, '18, '21, '24 & '27

The capacity basis of design for the intercepting sewers of the Minneapolis-St. Paul Sanitary District included an allowance for stormwater runoff computed by using runoff factors ranging from 0.2 to 0.8 for hourly rainfall intensities up to 0.04 inches.

Dr. McKee has also adopted the 0.04 inches per hour rainfall intensity for determining sewer capacities of which he assumes that the first 0.03 inches will be taken up for wetting surfaces and the remainder will reach the intercepting sewers in proportion to the percentage of impervious area, i.e. his assumptions represent a runoff factor of 100% for fully wetted impervious areas and 0% for pervious areas.

Data from actual observations on intercepting overflows are practically unavailable. Accordingly, engineers have fallen back, like Dr. McKee, upon a "few logical assumptions" in order to compute overflow frequencies and magnitudes and thus forecast possibilities of the overflow of sanitary sewage into the river during rainstorms.

Sewage quantities for the planning of the Minneapolis-St. Paul intercepting sewers were based upon an extensive study of sewage flows, including many gagings. The capacities computed for three typical intercepting sewers may be summarized as follows:

Interceptor	Domestic Commercial and Industrial Sewage M.G,D,	Average D.W.F. M.G.D.*	Stormwater M.G.D.#	Interceptor Capacity M.G.D.	Interceptor Capacity Per Cent D.W.F.
"A"	80.90	106.95	130.59	297.62	278
"B"	45.22	56.52	62.85	149.52	264
"D"	163.01	213.44	266.32	594.07	278

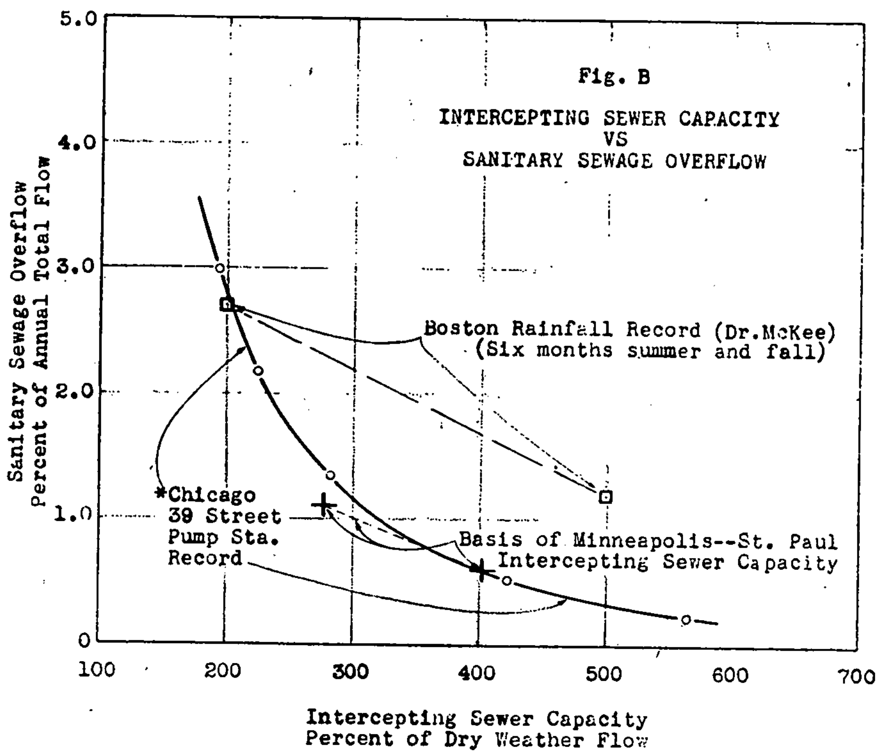
NOTES: * Dry weather flow estimated by adding ½ of the wet season ground water to the domestic, commercial and industrial flows.

Computed runoff for rainfall intensities of 0.04 inches per hour.

Increasing the sewer capacity to take twice as much storm-water would give the following capacities:

Interceptor	Intercepting Sewer Capacity M.G.D.	Per Cent D.W.F.
"A"	428.21	400
"B"	212.37	375
"C"	860.39	403

During the computations it was determined that the percentages of sanitary sewage overflowing to the river related to sewer capacity, in terms of dry weather flow, would be 1.1% for a sewer capacity equal to about 278 per cent of dry weather flow and 0.6% for a sewer



* Computed from probability curve in Fig. 11, p. 848 of Davis "Handbook of Applied Hydraulics".

capacity equal to about 400 per cent of dry weather flow. Dr. McKee included the 1.1% and 0.6% figures, but did not properly interpret the sewer capacities.

Chicago, Illinois, has combined sewers and the sewage is pumped into sewers leading away from Lake Michigan. A record of pumpage rates for the 39th Street Pumping Station plotted on logarithmic probability paper, given in Davis' "Handbook of Applied Hydraulics" (Fig. 11, p. 848), shows a decided upturn in the chart for percentages of time less than 5.27%, undoubtedly due to the effect of storm water flows.

A similar upturn appears in the probability plotting, in the same diagram, of the 1914 record of sewage flows at Cleveland which were also from combined sewers.

Computations based upon the above referenced Chicago curve, have developed the following percentage quantities of domestic sewage which would overflow with various sewer capacities in terms of dry weather flow, if intercepting sewers were provided with such capacities at Chicago.

Intercepting Sewer Capacity		
Percentage of Yearly Average Sewage Flow	Percentage of D.W.F.*	Computed Per Cent of Total Annual Sanitary Sewage Flow Which Would Be Discharged Through Stormwater Overflows
140	197	3.00%
160	226	2.18%
200	282	1.35%
300	423	0.53%
400	564	0.23%

* D.W.F. = dry weather flow. The yearly average flow at 39th street was 141% of D.W.F.

Plotting these several estimates of percentage loss of sanitary sewage against intercepting sewer capacity as shown by Fig. B, indicates a remarkably close agreement in all three estimates, excepting for Dr. McKee's figure of 1.2 per cent loss of sanitary sewage for an intercepting sewer capacity of five times the dry weather flow.

The Chicago 39th Street Pumping Station data indicate that the amount of sanitary sewage overflowing would be about 0.3 per cent as compared to Dr. McKee's theoretical figure of 1.2 per cent.

However, more important than these overall figures of annual loss of sanitary sewage or even the figures of summer-time losses, would be a record of frequency and duration of overflow with the resulting effect on the river conditions, which might be obtained from a study of some existing intercepting sewer system.

NOTE BY J. E. MCKEE: The discrepancy between Professor Stanley's data for Minneapolis-St. Paul and the theoretical results of the Boston study is, to a large degree, attributable to the fact that the Boston analysis was based on a combined sewerage system for the entire area served whereas the Minneapolis-St. Paul data are derived from a sewerage system containing both combined and separate sewers. For example, Interceptor "A" at Minneapolis-St. Paul (see the Second Annual Report, Metropolitan Drainage Commission of Minneapolis and St. Paul, 1928) serves a total area of 46,389 acres of which only 15,321 acres, or 33%, have combined sewers. Assuming the same run-off coefficients to apply over the entire area, the storm-water run-off if the entire 46,389 acres had been served by sanitary sewers would be

$$130.59 \text{ mgd} \times \frac{46{,}389}{15{,}321} = 395 \text{ mgd for } 0.04 \text{ in. per hr of rainfall.}$$

This value is 370% of the average dry-weather flow and agrees quite closely with the theoretical Boston value of 400% for 0.04 in. per hr of rainfall. In fact, the dry-weather flow at Minneapolis-St. Paul corresponds to a run-off from 0.0108 in. per hr of rainfall, a close check on the 0.01 in. per hr derived for Boston.

The adjustments for areas served by separate sewers, if carried through the other computations for Minneapolis-St. Paul data, would show that the results there closely approximate the Boston study with the per cent of total annual overflow (see Professor Stanley's Fig. B) being increased for higher intercepting sewer capacities.

OVERFLOWS FROM SEWERS

BY T. A. BERRIGAN, Member*

(A discussion of Paper by J. E. McKee at meeting of Sanitary Section, B.S.C.E., held on March 5, 1947.)

At the outset, permit me to congratulate Dr. McKee on his paper entitled "Loss of Sanitary Sewage Through Storm Water Overflows." In my opinion, the thought expressed by Dr. McKee after careful study will enable the Public Health authorities to take immediate action in matters under their cognizance covering prohibition of the use of receiving waters for recreation or shell fish taking purposes. This may be accomplished by pre-determining the volume of the receiving prism of water, the available dissolved oxygen, concentrations of B. Coli, and the intensity and duration of the rainfall. It is noted in the paper that in the absence of precise data for runoff for low intensity rainfall, Dr. McKee assumes that only the rain that falls on impervious surfaces (after the first .03 inches which fills depressions and forms film) gets into storm drains or as otherwise expressed, "all precipitation upon vegetation and unpaved surfaces is considered to be evaporated, transpired or manifested as ground water." While this assumption may be challenged by many engineers concerned with stream gaging, the assumption appears logical when dealing with storm overflows from low intensity rainfalls.

The Chief Engineer of the Sewerage Division concurs with the findings of Dr. McKee respecting the inadvisability of constructing a sewerage system on the combined basis. This opinion is garnered from experience with Metropolitan sewers, Boston Main Drainage Works and the Merrimack River Valley Studies. Some time ago the Chief Engineer of the Metropolitan sewers was confronted at a legislative hearing by a legislator who criticized the program of requiring municipalities to expend considerable amounts of money to separate storm from sanitary wastes, and stated that the Metropolitan District Commission should build its sewers large enough to handle the flow from communities with combined systems. The program

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referred to is contained in an excerpt from General Laws, Chapter 92, Section 9, which is quoted as follows:

> "Any town, except Boston, using any metropolitan sewer may, in any year, and shall, in any year specified by the officer or board having charge of sewers, expend one twentieth of one per cent of its taxable valuation, to be met by loan outside the debt limit, in the construction, in connection with said sewers, of branch intercepting sewers, connections of existing sewers with intercepting sewers, branch drains, sewers or drains in any street where one thereof only shall have been built, and the necessary connections aforesaid.
>
> "The supreme judicial and superior courts may enforce this section."

This excerpt of course has reference to the construction of a separate sanitary system where in fact a single system is used to intercept storm drainage as well also as sanitary waste. On the occasion of the confrontation above referred to, the Chief Engineer of the Metropolitan Sewers stated that the building of sewers of adequate size to completely intercept combined sewage was beyond the capacity of the taxpayers and economically unsound. With particular reference to the Metropolitan Sewerage System, it may be stated that the following sections are served with combined systems: Somerville, Cambridge, a portion of Everett, Chelsea, Charlestown, East Boston, Brookline, Milton, Brighton, Roxbury, a portion of West Roxbury and Dorchester. The following sections served by Metropolitan sewers are considered to have separate storm water and sanitary systems: Arlington, Belmont, a portion of Everett, Lexington, Malden, Medford, Melrose, Reading, Revere, Stoneham, Wakefield, Winchester, Winthrop, Woburn, a portion of Dorchester, Hyde Park, a portion of West Roxbury, Braintree, Canton, Dedham, Needham, Newton, Norwood, Quincy, Stoughton, Walpole, Waltham, Watertown and Wellesley. At the present time the cost of new Metropolitan sewerage construction is covered by assessments which are levied in proportion to property valuations in the respective communities, since it appears reasonable to consider the respective communities as having a capital investment in the sewerage works. Maintenance and operation costs of the system are assessed upon the communities in proportion to the respective populations, it being theorized that Metropolitan sewerage service is rendered in proportion to the number of inhabitants. Communities with separate systems are already complaining about this taxable arrangement and advocating that maintenance and operation costs should be assessed on the basis of metered flow, thus penalizing communities which have failed to effect separation of storm and sanitary drainage. Recent legislation, and more particularly Massachusetts Laws of 1945, Chapter 705, Section 12, indicates the attitude of the Legislature in this regard by authorizing and directing the Metropolitan District Commission to make rules and regulations covering the discharge of waste and other drainage into the Metropolitan sewers and thereafter to assess special damages arising out of the breach of these rules and regulations. An excerpt from this citation is quoted as follows:

> "The metropolitan district commission is hereby authorized and directed to adopt, and thereafter may alter, amend and repeal, rules and regulations concerning the discharge of sewage, drainage, substances or wastes into any sewer under its control, or any sewer tributary thereto, within the north metropolitan sewerage district or the south metropolitan sewerage district. Failure on the part of any municipality within either of said districts to comply with any such rule or regulation, or with any order made under authority thereof, lawfully affecting such municipality, shall be sufficient cause for the levying and collecting by said metropolitan district commission from such municipality of such additional assessment or assessments as said metropolitan district commission may deem necessary to compensate it for the disposal of sewage, drainage, substances or wastes from such municipality; provided, that no such additional assessment shall be levied on any such municipality in any one year which shall exceed the lesser of an amount equal to one twentieth of one per cent of the taxable value of such municipality, or the sum of two hundred thousand dollars."

Property valuations in communities in North and South Metropolitan District total approximately $2,317,000,000 at the present time. In the fiscal year 1947, $1,000,000 was appropriated to cover the cost of maintenance and operation. From this it may be seen that if full force and effect be given to this legislation there is a possibility that an additional million dollars may be specially assessed. To show the deep concern which the Metropolitan District Commission has respecting combined sewerage systems it appears appropriate to quote a regulation which it is expected will be promulgated in pursuance of Mass. Acts of 1945, Chapter 705, Section 12:

> "No municipality shall contract for the building of additional sewerage works contemplated for connection into the metropolitan sewerage system until plans and specifications covering such works are submitted to and approved by the Chief Sewerage Engineer of the metropolitan district commission, and notice is hereby given that the metropolitan district commission views with disfavor any works designed on the so-called combined system

or the discharge of processing or condensing water which the department of public health determines is sufficiently free from contamination to permit its discharge into the nearest water course."

Persual of the records indicates that the Metropolitan Sewerage System consists of 156.3 miles of sewers and other appurtenances, such as pumping stations, etc. It is estimated that there are ten overflows on Metropolitan sewers and 130 overflows on local sewers contributing sewage to the Metropolitan System. It may be further stated that there are approximately 1,550 connections to Metropolitan sewers, many of which are equipped with regulators which discharge through the local overflows above referred to. In passing it should be stated that a limited number of overflow devices would be considered necessary even though a large trunk sewer handles only sanitary wastes since such devices act as safety valves to relieve surcharged conditions which would otherwise flood basement fixtures during a breakdown of pumping operations.

So far as the Chief Engineer of the Sewerage Division has observed, all regulators adjacent to the Metropolitan lines operate to exclude all local sewage when the Metropolitan sewer is flowing at full capacity, in which event all of the local sewage is discharged into the nearest water course and the Metropolitan sewer is unavailable. Apparently these regulators accomplish something different from the regulators referred to in Dr. McKee's paper. Regulators adjacent to Metropolitan sewers are of the floating type, which actuate a lever and seal off the connection by a horizontal or vertical motion of the sealing device. Many of the floats are contained in a so-called bathtub arrangement which reduces pulsation and takes the hunting out of the device. In view of the type of regulators used on Metropolitan lines, it should be appreciated that the Metropolitan sewers are not available to communities located at the lower end during times of heavy rainfall and that whether or not the sewer is available is an inverse function of the intensity of the storm, for example, on the North Metropolitan System in times of heavy storms, Metropolitan facilities are available to sections such as Winchester and Woburn but they are not available to a section located such as Chelsea is. This arrangement, however, does have one desirable result, to wit, overflows occur where dilution factors are higher. In passing it may be stated that similar conditions obtain in the Boston Main Drainage Works and more particularly to the fact, sections of Roxbury are postponed to the

Back Bay District and that such postponement was contemplated in the original design.

To more particularly correlate the experiences of the Metropolitan Sewerage Division with the thought expressed in Dr. McKee's paper, it may be stated that the original North Metropolitan trunk sewer was designed in 1890 and predicated on an assumption that 513,000 persons would be served in 1930, and a further assumption of 30 cu. ft. per capita per day, except for an area of Cambridge and Somerville where 35 cu. ft. per capita per day was assumed. The capacity of the system in the vicinity of Chelsea Creek amounts to 122 M. G. D. It is also noted that the area contemplated for drainage amounts to 44 square miles. It is interesting to note in this connection that if the 513,000 persons contributed 75 gallons per capita per day, then 38 M. G. D. is available in the trunk sewer to handle sanitary wastes, thus leaving a balance of 84 M. G. D. for storm water. This 84 M. G. D. is about equivalent to .01 of an inch of rainfall per hour on the basis that one-half of the 44 square miles of area is paved. Bringing the consideration up to date, it may be stated that the old North Metropolitan Sewer in the vicinity of Chelsea Creek has a capacity of 122 M. G. D. and that adjacent thereto there is now existent a relief sewer with a rated capacity of 340 M. G. D. Further, it is presently observed that the old trunk sewer of 122 M. G. D. is just adequate to handle the dry weather flow. Having in mind Dr. McKee's studies and the ratio between the old trunk sewer and the new relief sewer, it may be stated that overflow from the relief sewer does not occur until there is an intensity of rainfall of .03 inches per hour after the first wetting of .03 inches. Further consideration of the proposition expressed by Dr. McKee indicates that 20% of the sanitary sewage or approximately 24,000,000 gallons of sewage per day escape into the adjacent water course during a rainfall intensity of .04 inches per hour after the first wetting of .03 inches.

Perusal of Boston Main Drainage documents indicates that the system was designed to serve a population of 800,000 people at an average contribution of 75 gallons per day and that a 50% increase or 112.5 gallons per day was contemplated for peak loads. Multiplying the peak load by the population of 800,000 gives 90 M. G. D. as a peak dry weather flow. The documents further stated that the system is designed to also handle a quarter of an inch rainfall per day and that the area served which is very substantially paved amounts to 20 square miles. It is interesting to note in this connection that 20 x 5,280 x 5,280 x 1/12 x ¼ x 7½=88 M. G. D. which corresponds very closely to the 90 M. G. D. flow above referred to as the peak sanitary contribution.

Dr. McKee's paper is of too recent origin for the Chief Engineer to determine how closely the dry weather flow in Metropolitan sewers compares with the .01 inch per hour of rainfall referred to or to establish other relationships between duration of rainfall and flow in Metropolitan sewers.

The basic idea in Dr. McKee's paper concerns the degree of pollution of receiving waters. Attention is invited to the fact that improperly maintained tide-gates, low manholes adjacent to rivers, unconscionable amounts of infiltration of local sewers and inadequate pumping capacity also reduce the available capacity for sanitary sewage and effect a premature discharge of sewage through overflows. There is no justification for these latter conditions and it is the opinion of the Chief Engineer of the Sewerage Division that sufficient assessments should be immediately levied to abate such of these nuisances as now obtain.

AUTOMATIC SPRINKLER SYSTEMS

BY RICHARD W. NEWCOMB, Member*

(Presented at a meeting of the Northeastern University Section of the Boston Society of Civil Engineers held on December 4, 1946).

The general field of fire protection engineering includes many specialized branches in which engineers of all backgrounds may find activity which embraces their particular specialty. Before we examine the automatic sprinkler system and some of the features and problems inherent in its design and operation let's look at some of the over-all and specific objectives of fire protection engineering. Basically the fire protection engineer is concerned with loss prevention. The largest staffs of fire protection engineers are maintained by insurance organizations who insure large industrial properties against loss by fire, explosion, lightning, wind, and similar hazards.

The civil engineer finds in the fire protection field many activities in which he can apply his particular training and background. Civil engineers deal with the hydraulics of fire protection in all its many ramifications—the design and layout of water supplies for fire protection at industrial properties, the design of automatic sprinkler systems, determining the reliability of fire pumps, valves and other features of hydraulic fire protective systems. These engineers also work closely with public water authorities to maintain adequate public water supplies and with health authorities to safeguard public water supplies against contamination. The construction engineer working in fire protection covers all phases of plant building construction from the standpoint of safety from fire and wind damage, such as safe designs of tanks and towers, the safe use of welding, safe roof anchorage design to resist uplift by wind, and other similar problems in construction.

Having examined in this brief way the fire protection engineering field and some of the activities which a civil engineer is qualified to pursue in fire and loss prevention let's proceed to our principal topic—the automatic sprinkler system.

*Student, Northeastern University, Boston, Mass.

Discussion

An automatic sprinkler system provides an army of mechanical watchmen who are constantly on duty to discover and control incipient fires. The automatic sprinkler system is not hampered or handicapped because of heat, smoke or gases which are prevalent at most fires and which greatly curtail the activities of human fire-fighters. When fire breaks out in a portion of a building only those sprinkler heads directly over the seat of the fire release water, hence the most effective utilization of the fire-service water supply is achieved with a resulting minimum of water damage. Automatic sprinklers usually extinguish any fire while it is still in its infancy, always minimizing the spreading of the fire and the damage to adjoining property.

The benefits of automatic sprinkler protection in an industrial property have many and far-reaching ramifications. It protects and sustains human lives and preserves large taxable properties. Through the subsequent curtailment of fire loss obtained by the protection provided by the installation of an automatic sprinkler system in large buildings, interruptions of business, educational and cultural endeavors are prevented. In industrial properties as a factor in sustaining and expediting production, automatic sprinkler protection is of paramount importance. A serious fire resulting in the loss of a vital process can easily bottle-neck production for weeks or even months with the serious consequences of loss of capital and failure to fulfill commitments for shipments of the finished product. With some of the benefits and functions of an automatic sprinkler system now clearly defined, let us examine the system itself and its important component parts.

An automatic sprinkler head may be defined as a mechanical device, that when heated to a predetermined temperature, automatically releases and distributes a spray of water which throughly wets the roof, floor and contents of an area of about 60 sq. ft. The essential parts of a sprinkler head in order of importance are a releasing device, a nozzle and a deflector which distributes the water evenly over the roof and contents. The releasing device is a fusible link made of solder. All modern sprinkler heads with but two exceptions rely on the melting of the solder piece for actuation.

The frame and diaphram of the head are bronze. The orifice is kept closed by a small semi-spherical glass disc kept in place by a fusible link. The fusible link consists of a key piece, a strut and hook piece. At the top of the frame a deflector is attached which has a set of teeth projecting from its circumference to aid in the distribution of the water. The fusible link is composed of solder materials which will fuse at temperatures exceeding 50 degrees above the normal temperature of the room.

The sprinkler heads are attached to lines of pipe known as branch lines. These branch lines are suspended from the ceiling of a room by wrought-iron U-type hangers. The branch lines always are installed to drain back from the end heads on a line to larger centrally-located mains known as horizontal feeder mains. The feeder mains extend out of a vertical pipe known as the automatic sprinkler riser which is the central point of distribution for the area. The sprinkler control valve is located on the riser when outside control valves are not practical. This interior type of control is not recommended due to the possibilities of the valve being shut and inaccessible in case of fire. The main purpose for installing any sprinkler control valve is to shut off the water flowing into the riser, after a fire has occurred so as to prevent needless water damage.

The piping and valves, which comprise the connecting system between the source of water supply and the automatic sprinkler risers, is known as the yard system. Yard piping to sprinkler risers should be of ample size to supply sufficient water without undue loss by friction due to excessively long runs of pipe. Loops should be avoided whereever possible. The pipe should be laid well below the frost level, the exact depth varying according to local climatic conditions and the character of the soil. In northern states 5 feet of cover is usually sufficient and in southern states 3 feet of cover is usually satisfactory.

An outside control valve should be installed for each riser and located about 40 feet away from the building. The indicator post gate valve is the most desirable type of outside control valve. But where local conditions prevent the installation of this type of valve, as for example, where the entire available space is used for storage or a driveway, an outside-screw-and-yoke valve installed in a pit is satisfactory. These valve pits should be frost-proof and waterproof. At sprinkler installations where none of these methods of control can be used it may be necessary to depend on the city gate valve located on the connection between the public water main and the yard piping system, but this is not a desirable arrangement.

The water supply for the sprinkler heads may come from any of the following sources: public water main, elevated tank, or fire pump taking suction from some pond or reservoir located nearby. Supplies from two independent sources are necessary for thorough protection of large value properties. A connection from a public water system of good pressure constitutes the ideal source of water supply. These public water mains are usually located in the streets adjacent to the property. A fire-pump of sufficient capacity taking suction from a pond or reservoir of inexhaustible capacity is another excellent source of water supply. Elevated tanks of capacities fitting the size and requirements of the plant are acceptable where either of the aforementioned sources of water are not available. In any event the source of water supply should be capable of maintaining at least 15 lb. pressure at the highest sprinkler heads in any building of the plant. A single check valve or a set of double check valves should be installed on each connection to the yard system from public mains, pump or elevated tank. These valves maintain the pressure on the system by allowing the water to flow in one direction only. Also they prevent the pollution of potable water by non-potable water. The elevated tank is the least desirable source of water supply because of its fixed moderate capacity.

Automatic sprinklers are needed throughout all buildings having combustible construction or combustible contents of value. Before the interior sprinkler head layout is designed, the rooms to be sprinkled should be prepared by removing all unnecessary construction and any obstacles which might obstruct the proper operation of the sprinklers. All needless partitions, platforms and ceiling sheathing should be removed. Construction plans showing the essential features of the roof construction of the areas to be sprinkled should be obtained. The following discussion of sprinkler design will embrace the general requirements of risers and sprinkler piping layouts under various types of roof construction.

Risers should generally be centrally located with reference to the group of sprinklers which they supply. The size of risers is generally governed by the maximum number of sprinklers to be supplied. The size of risers and branch lines can be determined from the accompanying table. Branch lines should ordinarily be limited to six heads. The volume of water necessary to effectively supply a large number of sprinklers operating at once, indicates the desirability of an arrangement of branch lines to completely cover all points, so that a fire may be controlled at the start by the operation of a few heads.

It is essential for good protection that sprinklers be so arranged under combustible construction that the ceilings will be protected, that is, thoroughly wetted by water from the sprinklers. A sprinkler head with a deflector located 6 in. below the ceiling is satisfactory in attaining this result, having the usual 15 lb. pressure available at the heads. With higher water pressures, the discharge will be greater, but the thoroughly wetted area will not be measurably increased.

A two-inch drain connection, controlled by a globe valve and piped to a suitable location should be provided near the base of each riser. To facilitate their use for testing, such drains should be preferably discharged outside the building. All sprinkler pipes should be designed so as to drain back to the riser. For systems of less than fifty sprinklers, 2 in. drains are acceptable.

Under plank-on-timber roof construction at least one sprinkler should be provided for every 80-90 square feet of ceiling area. The intervals between heads should be uniform and the distance from the wall to the first head should not exceed one-half the allowable distance between sprinklers in the same direction. One line of sprinklers should be placed midway between the beams in each bay and the distance between heads on each line for ordinary occupancies should conform with the following figures:

8 feet in 12-foot bays
9 feet in 11-foot bays
10 feet in 10-foot bays
11 feet in 9-foot bays
12 feet in 8-foot bays

Under non-combustible construction at least one sprinkler should be required for each 100 square feet of area, with the maximum distance between heads not exceeding 12 feet. Non-combustible construction refers to reinforced concrete, gypsum, steel deck or similar roof materials. This is the simplest type of roof construction for which to design a sprinkler lay-out. It is not essential that all parts of the ceiling be wet; the main object being to protect the contents of the room and to keep any exposed steel members cool. Under non-combustible roofs, branch lines may be run in either direction.

Under roofs of joisted construction at least one sprinkler should be provided for every 70-80 square feet of ceiling area. Branch lines must be run at right angles to, or across, the joists and the heads must be staggered. The usual design is to locate heads on any line opposite points half way between heads on the adjacent lines. The maximum allowable distance between sprinkler heads on lines is 8 feet and the maximum allowable distance between lines should ordinarily be limited to 10 feet. The maximum distance between end sprinklers and walls, in any case, should not exceed half the distance between sprinklers in that same direction. Joisted construction is the most difficult to protect because the sprinkler discharge to the ceiling is broken up by the joists. The main underlying principle in joisted sprinkler layout design is to permit the discharge of water into as many pockets between the joists as possible.

Irrespective of the roof construction after a sprinkler layout has been designed and installed the system should be subjected to a hydrostatic pressure of not less than 200 lb. This test presssure should be maintained by a small utility pump for at least two hours, and all leaks stopped, and any defects remedied. Even after this test has been applied, the system cannot be expected to function properly unless the following maintenance practices are conformed to.

The sprinkler heads should be coated with wax as protection against corrosion. Sprinkler heads should never be painted, as paint may interfere with the free movement of parts and render the head inoperative. The useful life branch lines and risers can be prolonged by the application of a protective coating of red lead in varnish. Flow tests through the riser drain pipe should be made at regular intervals, which will indicate that the sprinkler system is under pressure, and will detect a shut valve, or frozen obstructed piping. The most important single item in the automatic sprinkler system is the sprinkler control valve, because sprinklers are useless without water. The sprinkler control valves must be kept open.

A valuable addition to an automatic sprinkler system is some type of water flow alarm. A water flow alarm is a device which will sound an alarm indicating that a flow of water has occurred in the riser in which it is installed. These alarms are important in buildings where the prompt discovery of fire is of particular importance or where water damage might be unusually large. Flow alarms are desirable supplements to watchman's service because, where there is no alarm, the interval between the watchman's rounds may sometimes allow considerable time to elapse before a fire on opened sprinkler is discovered.

One type of flow alarm is the Alarm Check Valve which is similar in design to a regular check valve except that it usually has a small pilot valve which admits water to the alarm device, through a retarding chamber when the flow at least equals that for a single sprinkler head. The retard chamber is provided to prevent false alarms due to surges; water hammer, on other short duration flows. Attached to the retard chamber is a length of pipe which connects to the actual alarm devices. For a general alarm in a mill yard a water motor alarm will give reliable service. The gong being located on the wall outside the building near the sprinkler riser. In addition to the water motor alarm an electric alarm actuated by a pressure switch or circuit closer located in the alarm line from the retard chamber should also be provided. In large properties the electric signal device is often wired to an annunciator board located at a well attended central location.

Another type of water flow alarm is the flow indicator. Flow indicators usually consist of a flexible paddle-like vane projecting into the waterway of the sprinkler riser. Movement of the water deflects the vane which causes an alarm actuating switch to close. Retard devices based usually on differential heat coefficients of bimetallic strips or in conjunction with recycle relays are employed to prevent false alarm due to surges in the system. The flow indicator gives an electric alarm only. To install a flow indicator the water supply is shut off and the system drained. A hole is cut in the wall of the riser and the flexible vane is rolled up and inserted in the pipe and the device is clamped in place and the necessary electrical connections to the alarm device are wired in place.

The automatic sprinkler system which we have been discussing is a wet system, that is water fills all the sprinkler piping and is available immediately beneath the valves of the sprinkler heads. Several other special sprinkler systems employed under particular conditions are worth mentioning. The first of these is the so-called dry-pipe sprinkler system. In a dry-pipe system the pipes normally contain air under pressure, instead of water. When a sprinkler head opens air escapes and water is admitted automatically by the operation of a dry-pipe valve. After the dry-pipe valve trips the sprinkler system functions as a regular wet system. Dry-pipe systems are employed in buildings where it is not practicable to keep the temperature above freezing with a reasonable sized heating plant and in refrigerated areas. The operation of the system is slower than the wet-pipe type as air must escape from the sprinkler piping before the water reaches the open sprinkler. Records show that where sprinklers are controlled by a dry-pipe valve, a larger number of heads open and the fire and water damage is apt to be greater than where sprinklers are on a wet system. Protection is always interrupted while the dry-pipe valve is being reset which is undesirable.

Dry-pipe valves are designed so that a moderate amount of air pressure will hold back a much greater water pressure. The two types commonly employed are the differential and the mechanical type dry-pipe valves. In the differential type, air pressure holds the water clapper closed by means of a difference in areas on which the water and air pressures act. In the mechanical type the differential pressure condition is accommodated by a system of levers which connects between the air and water clappers.

Another type of sprinkler system is what is known as a deluge system. In a deluge system, sprinkler heads are of the open type, and immediately upon operation of the deluge valve, water is quickly delivered to all heads, and the entire area protected is wet down. Such sytems are used as protection of special hazards such as japan drying, lacquer spraying, pyroxylin storage on working or in other areas where rapid combustion of the contents is probable. Deluge valves are located in the riser supplying the area protected by the open-head system. A system of (H. A. D. 5) or heat-actuated devices are used to initiate the operation of the system. An H. A. D. is a rate-of-rise device which registers rapid temperature changes. When a rapid temperature rise occurs, the air in the shell of the H. A. D. expands which action can be used to transmit an air pressure change to the deluge valve causing it to trip on the expansion may cause an electrical circuit to close which will trip the valve electrically thru a suitable release and permit water to flow into the system.

Another special system is one in which a non-freeze solution is employed. Non-freezing solutions may be used for maintaining automatic sprinkler protection during the winter months in small unheated areas such as elevator penthouses which would otherwise require a water filled system to be shut off. Some of the solutions used are calcium chloride, carbon tetrachloride, glycerine and several other non-freeze solutions. Ordinarily a liquid seal employing light oil and carbon tetrachloride is used between the water and the non-freeze solution piping to adequately isolate the two liquids.

In closing I would like to point out that intelligent, industrial managements the world over whole-heartily endorse the record and value of the automatic sprinkler system, and recognize it as the greatest single invention ever made in the art of fire-fighting and loss prevention and the one which has done more to preserve property and protect life than any other single factor.

OF GENERAL INTEREST

PRIZES AWARDED AT ANNUAL MEETING ON MARCH 19, 1947

Clemens Herschel Award

TO PROF. JOHN B. WILBUR, MEMBER AND MR. OSCAR S. BRAY

Presentation made by President George A. Sampson

Prof. Charles O. Baird, Chairman of the Committee on Prize Awards, 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 this Society, and is awarded for a paper which has been particularly useful and commendable and worthy of recognition. This year two prizes were awarded, one to Prof. John B. Wilbur, member, for his paper on "The Action of Impulsive Loads on Elastic Structures", presented at a meeting of the Main Society, held on March 20, 1946, and published in the July, 1946, JOURNAL; the second prize was awarded to Mr. Oscar S. Bray, for his paper, "The Mystic Cable Tunnel Design and Construction", presented at a meeting of the Designers Section held on December 12, 1945, and published in the July, 1946, JOURNAL.

The prizes consisted of books: To Prof. Wilbur: "Mechanical Vibrations", by Den Hartog; "Vibration Problems in Engineering", by S. Timoshenko; "Mathematical Methods in Engineering", by Carman Biot. To Mr. Bray: "Lincoln—The Prairie Years", Vol. I and II, by Carl Sandburg; "Shotgunning the Uplands", by Ray P. Holland.

Sanitary Section Award

TO ALLEN J. BURDOIN, MEMBER

Presentation made by President George A. Sampson

Mr. George G. Bogren, member of the Sanitary Section Prize Award Committee, consisting of Scott Keith, Herman G. Dresser and Mr. Bogren, outlined the purpose of the Sanitary Section Prize Award, 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 "Gas Engine Power for Sewage Treatment", by Allen J. Burdoin, member, presented at a meeting of the Sanitary Section held on October 3, 1945, and published in the January, 1946, JOURNAL.

The prize consisted of books: "Hydraulics for Engineers", by Robert W. Angus; "Heat Transmission", by William H. McAdams; "The Theory of the Gyroscopic Compass", by A. L. Rawlings; "Fundamentals of Hydro- and Aeromechanics", by O. G. Tietjens.

Designers Section Award

TO HENRY BRASK, MEMBER

Presentation made by President George A. Sampson

Prof. Albert G. H. Dietz, Chairman of the Designers Section Prize Award Committee, consisting of John R. Nichols, George W. Lewis and Prof. Dietz, outlined the purpose of the Designers 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 "Clamshell Bucket Unloading Towers", by Henry Brask, member, presented at a meeting of the Designers Section, held on February 13, 1946, and published in the July, 1946, JOURNAL.

The prize consisted of books: "Rahmenformeln - Kleinlogel" (Unger), Translation Key to Ditto; "The Oceans", by Sverdrup; "Don Grafs Data Sheets", Reinold Publishing Company.

Northeastern University Section Award

TO RICHARD W. NEWCOMB, MEMBER

Presentation made by President George A. Sampson

Prof. Charles O. Baird, Chairman of the Committee on Award of the Northeastern University Section Prize, consisting of George G. Bogren, Albert G. H. Dietz and Prof. Charles O. Baird, outlined the purpose of this prize, which was authorized in 1931, for a worthy paper by a student member.

The paper selected was that by Richard W. Newcomb, Student Member, and entitled "Automatic Sprinkler System", presented at a meeting of students at the University held on December 4, 1946, and published in the April, 1947, JOURNAL. The prize consisted of books: "American Civil Engineer's Handbook", Vol. I and II, by T. Merriman and T. H. Wiggin; "Fire Insurance Underwriting", by P. B. Reed.

Newly Elected Honorary Member

CHARLES WINSLOW SHERMAN

Presentation of Certificate by President George A. Sampson

Honorary Membership in the Boston Society of Civil Engineers was conferred on Mr. Charles Winslow Sherman at the Annual Meeting of the Society held on March 19, 1947. Following the Annual Dinner, President George A. Sampson presented the new Honorary Member a certificate of Honorary Membership, framed in a morocco leather case.

Mr. Charles Winslow Sherman has been a member of the Society since November 20, 1895.

The certificate of Honorary Membership reads as follows:

"In recognition of a long and distinguished career in the field of water works engineering and in the advance of engineering knowledge."

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS
Boston Society of Civil Engineers

JANUARY 22, 1947.—A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, Boston, Mass., and was called to order by President George A. Sampson, at 7:00 P.M. This was a joint meeting with the Hydraulics Section, B.S.C.E. Eighty-two members and guests were present and seventy-three persons attended the dinner.

President Sampson announced that the February meeting would be held on February 26, instead of February 19, our regular date and would be a joint meeting with the Transportation Section. The speaker will be Col. Enoch Needles, Consulting Engineer, Partner, Howard, Needles, Tammen & Bergendoff, New York. Subject, "Maine Turnpike Project".

President Sampson stated that a Petition to B.S.C.E. for a Resolution concerning salaries paid to Professional engineers in the employ of the Commonwealth, signed by five members of the Society was considered by the Board of Government at its meeting December 18, 1946, and that this present meeting had been designated by the Board for a discussion of such a Resolution, due notice having been given in the regular meeting notice in the E.S.N.E. Journal.

Mr. Francis H. Kingsbury read the proposed Resolution, which was as follows:

RESOLUTION

WHEREAS, in the opinion of the Board of Government of the Boston Society of Civil Engineers, the salaries of professional engineers engaged in service of the Commonwealth of Massachusetts are considerably below the salaries paid by the Federal Government and those recommended by the American Society of Civil Engineers and

WHEREAS, these engineers are required by law to pass upon plans for works which require the services of properly qualified engineers, and

WHEREAS, the present salaries offered for new employment are such that they are not attractive to properly trained engineers nor sufficient to retain proper engineering personnel in the higher grades,

THEREFORE, Be It Resolved that the Board of Government of the Boston Society of Civil Engineers recommends to the Joint Committee on Ways and Means of the General Court of Massachusetts that serious consideration be given to a readjustment of the salaries of the engineering personnel employed by the Commonwealth.

It was moved and seconded that the Resolution be adopted by the Society.

Mr. Kingsbury moved that the wording of the Resolution be changed by deleting the words "Board of Government of the" in the first and last paragraphs, so that the Resolution will be in suitable form for adoption by the Society; this motion was seconded; and another motion was made to change the wording of the last part of the last paragraph, so as to read ". . . that action be taken to provide for upward readjustment of the salaries of the engineering personnel employed by the Commonwealth."

VOTED that both amendments be adopted.

The amended form of Resolution was then voted upon. Forty-five members out of the sixty present, voting in favor of the adoption of the Resolution.

RESOLUTION

WHEREAS, in the opinion of the Boston Society of Civil Engineers, the salaries of professional engineers engaged in service of the Commonwealth of Massachusetts are considerably below the salaries paid by the Federal Government and those recommended by the American Society of Civil Engineers and

WHEREAS, these engineers are required by law to pass upon plans for works which require the services of properly qualified engineers, and

WHEREAS, the present salaries offered for new employment are such that they are not attractive to properly trained engineers nor sufficient to retain proper engineering personnel in the higher grades,

THEREFORE, Be It Resolved that the Boston Society of Civil Engineers recommends to the Joint Committee on Ways and Means of the General Court of Massachusetts that action be taken to provide for upward readjustment of the salaries of the engineering personnel employed by the Commonwealth.

The President stated that the majority of members present having voted in favor of the Resolution this matter will be referred to the members of the Society for letter ballot to be canvassed at the next meeting of the Society to be held on February 26, 1947, fixed by vote of the Board of Government on December 18, 1946.

President Sampson called upon Prof. Harold A. Thomas, Jr., Chairman of Hydraulics Section to conduct any necessary business for that Section.

President Sampson introduced the speaker of the evening, Mr. Nathan B. Jacobs, President, Morris Knowles, Inc., Engineers, Pittsburgh, Pa., who gave a most interesting talk on "The Water System of the City of Philadelphia and the Proposed Supply from Upland Sources". The talk was illustrated.

A rising vote of thanks was given the speaker.

Adjourned at 9:00 P.M.

EVERETT N. HUTCHINS, *Secretary*

FEBRUARY 26, 1947.—A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, Boston, Mass., and was called to order by President George A. Sampson, at 7:00 P.M. This was a joint meeting with the Transportation Section, B.S.C.E. One hundred sixty-eight members and guests attended the meeting and one hundred thirteen members and guests attended the dinner preceding the meeting.

President Sampson announced the death of the following member:

Frank S. Bailey who was elected a member September 21, 1898, and died January 21, 1947.

The Secretary reported on the election of the following new members:

Grade of Member.—*John L. Bean, Francis T. Bergin, Henry E. Bilodeau, Paul S. Crandall, Harold J. Duffy, Otis D. Fellows, *Donald G. Fogarty, Edwin J. Fitzgerald, George B. Garrett, Jr., Myle J. Holley, Jr., *Francis T. Ledgard, Charles T. Main, 2nd, Edward R. Marden.

Grade of Student.—Paul A. Dunkerley, Joseph F. Quinn, Jr.

Mr. Chester J. Ginder presented the Report of the Tellers, F. N. Weaver and J. F. Brittain, on the ballot on the Resolution regarding salaries of professional engineers engaged in the service of the Commonwealth, action on which was taken at the Society meeting, January 22, 1947, referring this matter to the whole membership of the Society. He stated that there were 316 ballots cast in favor of and 11 opposed to the Resolution. The President declared that the Resolution has therefore been adopted as follows:

*Transfer from Grade of Junior.

RESOLUTION

WHEREAS, in the opinion of the Boston Society of Civil Engineers, the salaries of professional engineers engaged in service of the Commonwealth of Massachusetts are considerably below the salaries paid by the Federal Government and those recommended by the American Society of Civil Engineers and

WHEREAS, these engineers are required by law to pass upon plans for works which require the services of properly qualified engineers, and

WHEREAS, the present salaries offered for new employment are such that they are not attractive to properly trained engineers nor sufficient to retain proper engineering personnel in the higher grades,

THEREFORE, Be It Resolved that the Boston Society of Civil Engineers recommends to the Joint Committee on Ways and Means of the General Court of Massachusetts that action be taken to provide for upward readjustment of the salaries of the engineering personnel employed by the Commonwealth.

The Secretary therefor was directed to send a copy of the Resolution to the Committee on Ways and Means of the General Court of Massachusetts.

President Sampson called upon Mr. Francis T. McAvoy, Chairman of the Transportation Section to conduct any business matters necessary for that Section.

President Sampson requested Prof. John B. Babcock to introduce the speaker of the evening, Col. Enoch R. Needles, Consulting Engineer, Partner, Howard, Needles, Tammen and Bergendoff, New York, who gave a most interesting paper on "Main Turnpike Project". The talk was illustrated with slides and numerous questions after the talk indicated the interest of the members in this project.

A rising vote of thanks was given the speaker.

Adjourned at 9:00 P.M.

EVERETT N. HUTCHINS, *Secretary*

MARCH 19, 1947.—The ninety-ninth annual meeting of the Boston Society of Civil Engineers was held today at the Hotel Vendome, 160 Commonwealth Avenue, Boston,, Mass., and was called to order at 4:30 P.M., by the President, George A. Sampson.

President Sampson expressed regret concerning the illness of Mr. Hutchins and paid tribute to his long service as secretary. By a rising vote the Secretary pro-tem was instructed to convey the best wishes of the Society to Mr. Hutchins.

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 on the election of the following new members:

Grade of Student.—Stuart E. Allen, Carmen A. Barletta, Richard A. Brackley, Daniel E. Braman, James H. Brown, Jr., Sumner B. Chansky, Paul G. Cleary, Joseph J. Colarusso, Thomas J. Connolly, Frederick E. Cook, Edward Danzinger, William J. Downey, Jr., David A. Duncan, Ralph P. Dyer, Hazel R. Eschelback, William R. Gorrill, Robert O. Harlow, Richard S. Johnson, Robert D. Keegan, Frederick D. A. King, Jr., Aaron M. Kreem, Albert J. Magee, Lawrence J. McCluskey, Robert J. McCourt, Philip J. McNamara, Carl J. Mellea, James F. Mullen, George F. Murphy, Arthur L. Quaglieri, Frank B. Reynolds, Philip A. Rossetti, Charles A. Rowley, Albert Salloom, Stanley Shuman, Clifford E. Sullivan, Jr., William T. Thistle, Peter C. Tornabene, Alfred J. Urban, Sumner J. Weinstein, Louis M. Wise, Erwin N. Ziner.

The Annual Reports of the Board of Government, Treasurer, Secretary and Auditors were presented. Reports were also made by the following committees: Hospitality, Welfare, Library, John R. Freeman Fund and Subsoils of Boston.

VOTED that the reports be accepted with thanks and placed on file and that they be printed in the April, 1947, 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, C. Frederick Joy, Jr., and Herman G. Dresser, was presented and in accordance therewith the President declared the following had been elected officers for the ensuing year:

President—Harvey B. Kinnison
Vice-President (for two years)—Everett N. Hutchins
Secretary (for one year)— Edwin B. Cobb
Treasurer (for one year)—Chester J. Ginder
Directors (for two years)—George W. Coffin, Herman G. Protze
Nominating Committee (for two years)—Dean Peabody, Jr., William L. Hyland, Walter E. Merrill.

The retiring President, George A. Sampson, then gave his address on "Civil Engineering—A Profession".

Seventy-five members and guests 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.

President Sampson expressed regret concerning the illness of Mr. Hutchins and paid tribute to his long service as Secretary.

Presentation of Prizes

President Sampson, requested Prof. Charles O. Baird, Chairman of the Committee on Awards, to outline purpose of the Clemens Herschel Award and to present the candidate. The President on behalf of the Society, then made the presentation of the Clemens Herschel Award to Prof. John B. Wilbur, member, for his paper on "The Action of Impulsive Loads on Elastic Structures", presented at a meeting of the Main Society, held on March 20, 1946, and published in the July, 1946, JOURNAL. The prize consisted of the following books:

"Mechanical Vibrations", by Den Hartog
"Vibration Problems in Engineering", by S. Timoshenko
"Mathematical Methods in Engineering", by Carman Biot.

President Sampson requested Prof. Albert G. H. Dietz, member of the Prize Award Committee to outline the purpose of the Herschel Award and to present the candidate. The President on behalf of the Society then made the presentation of a Clemens Herschel Award to Oscar S. Bray, for his paper on "The Mystic Cable Tunnel Design and Construction", presented at a meeting of the Designers Section held on December 12, 1945, and published in the July, 1946, JOURNAL. The prize consisted of the following books:

"Lincoln—The Prairie Years", Vol. I and II, by Carl Sandburg
"Shotgunning the Uplands", by Ray P. Holland.

President Sampson requested George G. Bogren, member of the Sanitary Section Prize Award Committee, to outline the purpose of the Sanitary Section Award and to present the candidate. The President on behalf of the Society, then made the presentation of the Sanitary Section Prize to Allen J. Burdoin, member, for his paper on "Gas Engine Power for Sewage Treatment", presented at a meeting of the Sanitary Section, held on October 3, 1945, and published in the January, 1946, JOURNAL. The prize consisted of the following books:

"Hydraulics for Engineers", by Robert W. Angus
"Heat Transmission", by William H. McAdams
"The Theory of the Gyroscopic Compass", by A. L. Rawlings
"Fundamentals of Hydro- and Aeromechanics", by O. G. Tietjens.

President Sampson requested Prof. Albert G. H. Dietz to outline the purpose of the Designers Section Prize Award and to present the candidate. The President on behalf of the Society then made the presentation of the Designers Section Prize to Henry Brask, member, for his paper on "Clamshell Bucket Unloading Towers", presented at a meeting of the Designers Section, held on February 13, 1946, and published in the July, 1946, JOURNAL. The prize consisted of the following books:

"Rahmenformeln-Kleinlogel" (Unger)
Translation Key to Ditto
"The Oceans", by Sverdrup
"Don Grafs Data Sheets", Reinold Publishing Company.

President Sampson requested Prof. Charles O. Baird to outline the purpose of the Northeastern University Section Prize Award and to present the candidate. The President on behalf of the Society then made the presentation of the Northeastern University Section Prize to Richard W. Newcomb, member, for his paper on "Automatic Sprinkler System", presented at a meeting of the Northeastern University Student Section, held on December 4, 1946. The Prize consisted of the following books:

"American Civil Engineer's Handbook", Vol. I and II, by T. Merriman and T. H. Wiggin
"Fire Insurance Underwriting", by P. B. Reed.

New Honorary Member

President Sampson then announced that Honorary Membership in the Society had been conferred on one of the Society's distinguished members, in accordance with the vote of the Board of Government on February 19, 1947, as follows: Charles Winslow Sherman, who has been a member since November 20, 1895. The President requested Mr. Arthur D. Weston to present the candidate. President Sampson then made the presentation of the Honorary Membership Certificate to Charles Winslow Sherman.

The certificate presented read as follows:

BOSTON SOCIETY OF CIVIL ENGINEERS

In recognition of a long and distinguished career in the field of water works engineering and in the advance of engineering knowledge

CHARLES WINSLOW SHERMAN

has been duly elected an

HONORARY MEMBER

By direction of the Board of Government
February 19, 1947
(Seal)

George A. Sampson
President
Everett N. Hutchins
Secretary

President Sampson then introduced the guest speaker of the evening, Dr. G. Edward Pendray, who gave a most interesting talk on "Jet Propulsion and Rockets".

At the conclusion of this address, President Sampson introduced the newly elected President, Harvey B. Kinnison, who then assumed the chair and adjourned the meeting.

One hundred eighty-eight members and guests attended the dinner.

Meeting adjourned at 9:30 P.M.

CHESTER J. GINDER,
Secretary, pro-tem

DESIGNERS SECTION

JANUARY 8, 1947. — Meeting was called to order by Chairman Peabody at 7:00 P.M. The clerk's report of the previous meeting on December 11, 1946, was read and approved. Following the usual custom at the January meeting, the chair appointed a Nominating Committee consisting of the three most recent chairmen with instructions to present a slate of officers at the February meeting. Balloting will not take place until the March meeting. This committee consists of Frank Lincoln, Chairman, Lawrence Gentlemen and Herman G. Protze.

The clerk, with the approval of the Executive Committee, announced that he had application blanks for membership in the American Concrete Institute available to any members of the group interested.

Professor Peabody introduced the speaker of the evening, Mr. R. H. Davies, Consulting Engineer from the Lincoln Electric Company. Mr. Davies discussed "Recent Progress in Structural Welding". The speaker began his talk by pointing out the low capital cost of welding as compared to riveting, illustrating his comments by noting in the western and southern part of the country, welding is much more widely used than in the east where so much money is tied up in heavy riveting equipment.

Some of the objection to welding in past are fast being eliminated as new test data is now out, simplifying and clarifying some of the previous unknown factors. A good illustration just how much a bad weld can stand was shown when the experiment of the Chicago Bridge and Iron Works was described. In this test, office workers made all the welds and the test results were surprisingly good.

Two sound films were shown illustrating the uses of welding and some of the precautions necessary in order to reduce the so-called "locked up stresses". After the showing of the films, Mr. Davies answered questions from the floor concerning electrode sizes and types, amperage and factors entering into the total cost of making welds such as poor supervision and poor fit-up.

Fifty-two members and guests were present.

Meeting adjourned at 9:30 P.M.

ERNEST L. SPENCER, *Clerk*

FEBRUARY 12, 1947.—After dinner at the Ambassador Restaurant, Chairman Peabody called the meeting to order at 7:00 P.M. in the Society Rooms, at 715 Tremont Temple. The clerk's report of the previous meeting on January 8, 1947, was read and approved.

The chair announced that, due to the lengthy procedure involved, the proposal of the Executive Committee that the name of the Section be changed to Structural Section would be turned over to the new officers for action.

A report of the nominating committee was read by Mr. Lawrence M. Gentlemen in the absence of the committee chairman, Mr. Frank L. Lincoln. The nominations presented were:

Chairman—Henry I. Wyner
Vice-Chairman—Ernest L. Spencer
Clerk—Robert W. Moir
Members of Executive Committee—Anthony S. Coombs, Oliver G. Julian, Chester A. Moore

The speaker for the evening, Mr. Arthur P. Grimm, Field Service Engineer of the A. M. Byers Co., was introduced by Professor Peabody. Mr. Grimm chose two topics for his discussion, (a) "Wrought Iron" and (b) "Radiant Heating and Snow Melting".

A sound motion picture was shown which clearly and concisely described Wrought Iron and traced its manufacturing history from ancient times right up through its present process at the new A. M. Byers Co., plant in Pittsburgh.

Mr. Grimm then showed several slides of some local radiant heating installations. These slides showed completed structures as well as installations in the process of being built.

The slides illustrated clearly the two types of installations usually used, namely, the head type and the continuous coil type. Several local snow melting jobs were illustrated and described.

An interesting discussion period followed the presentation of these pictures and slides.

Sixty-seven members and guests were present.

Meeting adjourned at 9:00 P.M.

ERNEST L. SPENCER, *Clerk*

MARCH 12, 1947.—After dinner at the Ambassador Restaurant, Chairman Peabody called the meeting to order at 6:45 P.M., in the Society Rooms, at 715 Tremont Temple. Retiring clerk Ernest L. Spencer's report of the previous meeting on February 12, 1947, was read and approved.

The report of the nominating committee was read by Chairman Frank L. Lincoln. The nominations presented were:

Chairman—Henry I. Wyner
Vice-Chairman—Ernest L. Spencer
Clerk—Robert W. Moir
Members of the Executive Committee—Anthony S. Coombs, Oliver G. Julian, Chester A. Moore

No other nominations were submitted.

The report of the nominating committee was accepted and the Secretary was instructed to cast one ballot for the slate as read.

Retiring Chairman Peabody paid tribute to his aides and the Executive Committee for the excellent support and capable assistance rendered him during the past year.

He then introduced the new officers and called upon the incoming chairman to say a few words. Chairman Wyner expressed the hope that the excellent and highly successful program of the past year would be continued and pledged himself to this end.

Chairman Peabody then introduced the speaker of the evening, Professor J. P. Den Hartog of the Department of Mechanical Engineering, Massachusetts Institute of Technology, who spoke on the subject "Vibrations, Their Effects and the Means to Avoid Them".

After amusing the audience by borrowing a match to light an electric lamp and then extinguishing the lamp by blowing it out, he proceeded with an enumeration of vibration problems with which he had dealt including a textile building, tall metal stacks, submarine periscopes, airplane wings, gas compressors, etc., and followed this with an analysis of the failure of the Tacoma Bridge.

Several models, varying in shape, were exhibited upon which a fan was made to blow which illustrated varying vibration and flutter tendencies. Unfortunately the stroboscope with which the speaker intended to measure the frequency of the vibrations in the models could not be operated on the D.C. current available in the Society Rooms.

It was pointed out that although the analysis of the forces causing vibration were at times extremely complex, the remedial measures frequently were simple. The speaker stated that 99% of all vibration problems could have been avoided by proper mechanical design. Means available to eliminate vibration in existing structures included (1) increasing the torsional resistance of the structure, (2) opposing the forces causing vibration by equal forces acting with the same frequency and (3) introducing forces which tend to interrupt the frequency of the vibrations.

A brief discussion period followed.

Forty-five members and guests attended.

The meeting was adjourned at 7:55 P.M. after a rising vote of thanks had been extended to Professor Den Hartog for a very interesting presentation.

ROBERT W. MOIR, *Clerk*

TRANSPORTATION SECTION

FEBRUARY 26, 1947.—A joint meeting of the Boston Society of Civil Engineers with the Transportation Section was held this evening in Chipman Hall, Tremont Temple. The meeting was called to order by George A. Sampson, President of the Society, at 7:00 P.M., and turned over to Francis T. McAvoy, Chairman of the Transportation Section for the transaction of the business of the annual meeting of the section. The report of the Nominating Committee was read nominating the following officers for the coming year; Chairman, George W. Hankinson, Vice-Chairman, R. Newton Mayall; Secretary, Herman Shea; Executive Committee, A. J. Bone, Francis T. McAvly and William L. Hyland. A motion was made and seconded that the clerk cast one ballot for these officers. The motion was carried and the officers were declared elected as nominated, completing the business of the section. Mr. McAvoy then turned the meeting back to Mr. Sampson.

The President, Mr. Sampson, then introduced the speaker of the evening, Col. Enoch R. Needles, partner in the firm of Howard, Needles, Tammen and Bergendoff, of New York, consulting engineers on the Maine Turnpike Project. Col. Needles discussed the Maine Turnpike, particularly the portion now under construction consisting of the 44 miles between Kittery and Portland. Besides the thoroughly modern high speed design features of this highway it also has the distinction of being financed entirely by revenue bonds, supported by the collection of tolls, without obligating the state tax funds or credit in any way. A number of interesting slides illustrated the design features of the project and scenes taken during the construction up to the present time. An interesting discussion followed the talk.

One hundred seventy members and guests attended the meeting.

Following a rising vote of thanks to the speaker, the meeting adjourned at 9:10 P.M.

THOMAS C. COLEMAN,
Acting Clerk

HYDRAULICS SECTION

JANUARY 22, 1947.—A joint meeting of the Boston Society of Civil Engineers with the Hydraulics Section was held this evening. Eighty-two members and guests attended the meeting, and seventy-three persons were present at the dinner.

The speaker of the evening was Mr. Nathan B. Jacobs, president of Morris Knowles, Inc., Engineers, Pittsburgh, Pa., who spoke on "The Water System of the City of Philadelphia, and Proposed Supply from Upland Sources". The talk was illustrated, and was followed by a discussion period.

The meeting adjourned at 9:00 P.M.

J. G. W. THOMAS, *Clerk*

FEBRUARY 5, 1947.—A meeting of the Hydraulics Section was held in the Society Rooms, 715 Tremont Temple, following a dinner at the Ambassador Restaurant.

During a business meeting conducted by Chairman Harold A. Thomas, Jr., the report of the nominating committee was read. In the ensuing vote the following were elected to serve as officers for the coming year:

Chairman—Leslie J. Hooper
Vice-Chairman—John G. W. Thomas
Clerk—James F. Brittain
Executive Committee—
Elliot F. Child, Gardner K. Wood, Byron O. McCoy

The speaker of the evening was Professor Arthur T. Ippen, Associate Professor of Hydraulics, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology, who spoke on "Standing Waves in Open Channels". The talk was illustrated with slides.

The talk was followed by a short discussion period, and the meeting adjourned at 8:45 P.M., with a rising vote of thanks to the speaker.

Twenty-eight members and guests attended the meeting.

J. G. W. THOMAS, *Clerk*

ADDITIONS

Members

Francis T. Bergin, 63 Ellison Park, Waltham, Mass.
Harold J. Duffy, 225 LaGrange Street, West Roxbury 32, Mass.
Edward J. Fitzgerald, 89 Pinkert Street, Medford 55, Mass.
Myle J. Holley, Jr., 131 Washington Street, Brighton 35, Mass.
Edward R. Marden, 76 Summit Avenue, Brookline 46, Mass.

Students

Stuart E. Allen, 131 Rowe Street, Auburndale 66, Mass.
Carmen Barletta, 107 Fisher Avenue, Roxbury 20, Mass.
Richard A. Brackley, 6 Bennett Street, Cambridge 38, Mass.
Daniel E. Braman, 7 St. Mark's Road, Dorchester 24, Mass.
Sumner B. Chansky, 23 Bertram Street, Beverly, Mass.
Paul G. Cleary, 181 Neponset Street, Norwood, Mass.
Joseph J. Colarusso, 709 Bennington Street, E. Boston 28, Mass.
Thomas J. Connolly, 312 East 8th Street, So. Boston 27, Mass.
Frederick E. Cook, 2200 West Street, Wrentham, Mass.
Edward Danzinger, 180 Cross Street, Malden 48, Mass.
William J. Downey, Jr., 2181 Washington Street, Newton Lower Falls 62, Mass.
David A. Duncan, 97 Ocean Street, Dorchester 24, Mass.
Ralph P. Dyer, 70 Myrtle Street, Somerville 43, Mass.
Hazel R. Eschelback, 19 Appleton Street, No. Quincy 71, Mass.
William R. Gorrill, 18 Wilson Place, Abington, Mass.
Robert O. Harlow, 103 Gainsboro Street, Boston 15, Mass.
Richard S. Johnson, 60 Westover Street, W. Roxbury 32, Mass.
Robert D. Keegan, 53 Barrows Street, Dedham, Mass.
Frederick D. A. King, Jr., 19 Webster Street, Hyde Park 36, Mass.
Aaron M. Kreem, 19 Fayston Street, Roxbury 21, Mass.
Albert J. Magee, 71 Westland Avenue, Boston 15, Mass.
Lawrence J. McCluskey, 24 Daniel Street, Arlington 74, Mass.
Robert J. McCourt, 34 Hopkins Road, Jamaica Plain 30, Mass.
Philip J. McNamara, 31 Phillips Street, Fitchburg, Mass.
Carl J. Mellea, 5 Oak Place, Hyde Park 36, Mass.
James F. Mullen, 23 Eden Avenue, West Newton 65, Mass.
George F. Murphy, 114 Washington Avenue, Waltham, Mass.
Arthur L. Quaglieri, 56 Woodbine Street, Boston 19, Mass.
Frank B. Reynolds, 68 Rhodes Avenue, E. Walpole, Mass.
Philip A. Rossetti, 6 Cedar Street, Charlestown 29, Mass.
Charles A. Rowley, 36 Bourndale Road, Jamaica Plain 30, Mass.
Albert Salloom, 62 Plantation Street, Worcester, Mass.
Stanley Shuman, 11 Lorna Road, Mattapan 26, Mass.
Clifford E. Sullivan, Jr., 257 Geneva Avenue, Dorchester 21, Mass.
William T. Thistle, 21 Charles Street, Wakefield, Mass.
Peter C. Tornabene, 372 Langley Road, Newton Centre 59, Mass.
Alfred J. Urban, 60 Homes Avenue, Dorchester 22, Mass.
Sumner J. Weinstein, 93 Ballou Avenue, Dorchester 24, Mass.
Louis W. Wise, Box 67, Lindsey Street, Attleboro, Mass.

DEATHS

WILFRED A. CLAPP, February 10, 1947
ALFRED O. DOANE, December 17, 1946
JAMES L. TIGHE, April 6, 1947

APPLICATIONS FOR MEMBERSHIP

[MARCH 15, 1947]

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

EDMUND H. BROWN, Natick, Mass. (b. July 9, 1912, Newton, Mass.) Attended Northeastern University from 1930 to 1931 then enrolled at Wentworth Institute and graduated in 1934. Experience, 1938, Metropolitan District Water Supply Commission as Junior Engineering Aid, held this rating until 1941 then promoted to Senior Engineering Aid. In 1942 was inducted into the Army and served with the Third Army, 5th Infantry Division, 449 Anti Aircraft Artillery until 1945 when discharged and returned to the Metropolitan District Water Supply Commission as Senior Aid. In 1946 promoted to Chief of Survey Party, which position I now hold. Refers to *J. P. Cavazzoni, S. M. Dore, C. J. Ginder, R. W. Moir, J. J. Vertic.*

CHARLES E. CYR, Lawrence, Mass. (b. September 14, 1908, Lawrence, Mass.) Attended public schools of North Andover, Mass. Received degree in Civil Engineering from Northeastern University in 1932. Experience, from June, 1932, was engaged in private practice. Winter of 1933-34, was employed by the Civil Works Administration; March, 1934 to March, 1935, engineer for contractor on 6½ miles of sewer, which included a pumping station and an outfall sewer; 1935 to 1937, engaged designing a fuel oil bulk plant and distributing system; 1937 to 1938, engaged in developing Mount Vernon Park, an one hundred sixty-five acre development. Since that time have been associated with the L. C. Cyr Construction Co., Lawrence, Mass., which furnishes a complete engineering and construction service for local industrial plants. This service is for sewer and water supply, culverts, roads, bridges, railroad spur tracks, and the rehabilitation of mill buildings. Between 1936 and 1941, also had my own private practice. At present am Vice-President and Engineer for the L. C. Cyr Construction Company. Registered in Massachusetts as a Professional Engineer, and as a Land Surveyor, and have been engaged by the Lawrence Housing Authority for Veterans Housing. Refers to *C. O. Baird, E. A. Gramstorff, J. Lasker, E. L. Spencer.*

WILLIAM B. HILTON, Lynn, Mass. (b. December 19, 1906, Danvers, Mass.) Attended grades schools at Danvers, Mass. Graduated from Northeastern University in 1929 with B.C.E. degree. Completed courses in structural and bridge engineering with the Wilson

Engineering Corporation of Cambridge, Mass. Experience, three years as transitman in the engineering department of the Eastern Massachusetts Street Railway Company; two years as construction engineer with Morton C. Tuttle Company, Boston, Mass.; City Engineers Department, City of Lynn, two years as transitman, four years as chief of party, eight years as assistant to the city engineer. With U.S.N. Construction Battalion as a Chief Carpenters Mate, for two years, discharged December, 1945. Registered Professional Engineer, State of Massachusetts. At present with the City Engineers Department, Lynn, Mass. Refers to *C. O. Baird, R. G. Bergstrom.*

Transfer from Grade of Junior

STEPHEN HASELTINE, Stoneham, Mass. (b. February 4, 1910, Sommerville, Mass.) 1927-1931, Northeastern University, Boston, Mass., graduated with degree of Bachelor of Civil Engineering. Experience, 1931-1936, employed by various road contractors as paving foreman and equipment operator. Salesman for construction equipment; 1936-1938, 1939-1941, partner in firm of Coffey and Haseltine, Civil Engineers and Surveyors, Melrose, Mass., making land development, land court and construction surveys; 1938-1939, 1941-1942, with Metcalf & Eddy, Boston, Mass., as assistant engineer, field engineer, draftsman and inspector on sewer construction, field surveys, airfield design, water distribution and sewerage design and layout, and sewage treatment plant design; 1942-1943, with Jackson & Moreland, Boston, Mass., as assistant engineer on sewerage and drainage design; 1943 with E. B. Badger & Sons, Inc., Boston, Mass., as piping draftsman on large oil refineries; 1943-1946, with U. S. Navy as Lieut. CEC, USNR, on active duty as Officer in Charge of Construction Battalion Maintenance Unit assigned to Public Works duty in Asiatic Pacific theater of operations; 1946 with Charles T. Main, Inc., Boston, Mass., as assistant engineer in design of dams and power development. At present with Metcalf & Eddy, Boston, Mass., as Project Engineer on design of water filtration plant. Refers to *C. O. Baird, C. E. Carter, E. B. Cobb, F. L. Flood, A. L. Shaw.*

HENRY A. KINGSBURY, Medfield, Mass. (b. April 26, 1921, Medfield, Mass.) Attended Northeastern University from 1939 to 1943, receiving B.S. degree in Civil Engineering, November, 1943. Experience, from 1936 to 1940, with Whitman & Howard, Boston, Mass., as transitman, draftsman and rodman; worked one year between April, 1941 and June, 1942, for Fay, Spofford & Thorndike, as an assistant engineer doing drafting, detailing and some design and estimating; 2½ months in 1943 with the Naval Design Section, Naval Advance Base Depot, Davisville, Rhode Island, on water supply layout and supervision; 2½ months in 1942 for Metcalf & Eddy at Wilmington, N. C., on a Bomber Command Station doing drainage design and layout. Went on active duty in the Navy in July, 1943, and served with the 30th Naval Construction Battalion overseas. Was a commissioned officer in the Civil Engineer Corps, U. S. Navy. Released to inactive duty in March, 1946. Since my release from the Navy have been with Metcalf & Eddy, Engineers, Boston, Mass.; work has been on design and layout work in connection with the preparation of construction drawings for treatment plants of various types. Refers to *G. W. Coffin, E. B. Cobb, E. A. Gramstorff, W. L. Hyland, J. W. Raymond.*

Transfer from Grade of Student

BERNARD A. BARNES, Staten Island, New York. (b. April 1, 1924, Staten Island, New York.) Graduated from New Dorp High School, Staten Island, New York, in 1942. Served in the Army in 1943. Graduated from Northeastern University in 1946, with B.S. degree in Civil Engineereing. Refers to *C. O.*

Baird, G. W. Hankinson, E. A. Gramstorff, E. L. Spencer.

Carl W. Eschelbach, West Newton, Mass. (b. November 25, 1923, Newton, Mass.) Graduated from Newton High School in 1943 and from Northeastern University, June 9, 1946, with B.S. degree in Civil Engineering. Experience, cooperative work, December, 1944 to March, 1945, City of Newton Engineering Department as rodman, draftsman. Refers to *C. O. Baird, G. W. Hankinson, E. A. Gramstorff, E. L. Spencer.*

John M. Campbell, Marlboro, Mass. (b. January 4, 1924, Inverness, Nova Scotia, Canada.) Graduated from Marlboro High School in 1941; from Northeastern University in June, 1946, with B.S. degree in Civil Engineering. Experience, cooperative work, chainman, Boston Consolidated Gas Company, April 12, 1943, to June 25, 1943; chainman, Boston & Albany Railroad, September 13, 1943 to March 11, 1944; transitman, W. S. Crocker, Civil Engineer, Boston, Mass., December 3, 1944 to May 26, 1945. Refers to *C. O. Baird, E. A. Gramstorff, L. A. Chase, E. L. Spencer.*

Alfred J. Pacelli, Quincy, Mass. (b. August 22, 1925, Boston, Mass.) Graduated from Northeastern University on February 2, 1947, with B.S. degree in Civil Engineering. Experience, cooperative work, December, 1944 to March, 1945, with Whitman & Howard, as rodman; Summer of 1945 at Portsmouth Navy Yard as transitman; June, 1946, to November, 1946, Norfolk County Engineers office as transitman and draftsman. Refers to *C. O. Baird, G. W. Hankinson, E. A. Gramstorff, E. L. Spencer.*

Donald B. Carter, Jr., Glastonbury, Conn. (b. March 25, 1924, Hartford, Conn.) Graduated from Hillyer Junior College, Hartford, Conn., in June, 1943, receiving degree of Associate of Science; graduated from Northeastern University, September 30, 1946, B.S. degree. Experience, cooperative work, December, 1944 to March, 1945, with Turner Construction Company, Boston, Mass., as timekeeper on construction work for Pratt and Whitney Aircraft Company in East Hartford, Conn.; March, 1945, to June, 1945, with New York, New Haven & Hartford Railroad Company, as chainman, rodman, instrument man and tracer. Refers to *C. O. Baird, G. W. Hankinson, W. E. Nightengale, E. A. Gramstorff, E. L. Spencer.*

Kenneth E. Palmer, Attleboro, Mass. (b. July 18, 1923, Attleboro, Mass.) Graduated from Attleboro High School, Attleboro, Mass., in 1941. Entered Northeastern University September, 1941, left July, 1944, to enter U. S. Army. Discharged September 28, 1945. Returned to Northeastern University, graduating June 9, 1946. Experience, cooperative work (10 week periods) at South Boston Navy Yard, as transitman on construction of a dry dock, November, 1942 to May, 1943, and for U. S. Coast & Geodetic Survey, at Rockland, Maine, as a photographic observer, July to September, 1943. Refers to *C. O. Baird, G. W. Hankinson, E. A. Gramstorff, E. L. Spencer.*

Francis R. Tinsler, Natick, Mass. (b. January 17, 1921, Boston, Mass.) Graduated from Northeastern University July 6, 1946, receiving B.S. degree in Civil Engineering, Experience, cooperative work, on alternate ten week periods, employed by H. N. Loomis, New Hartford, Conn., and the Metropolitan District of Hartford, Conn., as rodman, chainman, transitman, computing and layout work. Entered the service January 1, 1943, in the grade of private and was discharged August my work at Northeastern University. Refers to *C. O. Baird, G. W. Hankinson, E. A. Gramstorff, E. L. Spencer.*
6, 1945, with grade of 1st Lieutenant. My duty was 1st pilot on a heavy bomber. At present am completing

ANNUAL REPORTS

REPORT OF THE BOARD OF GOVERNMENT FOR YEAR 1946-1947

Boston, Mass., March 19, 1947

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 19, 1947.

Seventeen new members and 13 students have been added during the year, and 6 members, 4 juniors, and 5 students have been reinstated, making a total addition of 45 members.

During the year 8 members have died, 7 have resigned, 4 have been dropped for non-payment of dues, and 9 have been dropped for failure to transfer, making a total deduction of 28.

The present net membership of the Society consists of 8 honorary members, 643 members, 43 juniors, 23 students, 3 associates, making a total membership of 720, a net gain for the year of 17.

The honorary membership list is as follows:

Dr. Karl T. Compton, elected, February 17, 1932
Prof. C. Frank Allen, elected, March 16, 1932
Prof. Charles M. Allen, elected, January 14, 1942
Arthur W. Dean, elected, January 14, 1942
Charles R. Gow, elected, January 14, 1942
Arthur T. Safford, elected, January 26, 1943
Charles M. Spofford, elected, December 19, 1945
Charles W. Sherman, elected, February 19, 1947

Deaths

Members:

Gordon S. Rutherford, August 25, 1945
George S. Brush, April 28, 1946
George C. Danforth, June 30, 1946
Bertram L. Makepeace, August 14, 1946
Albert S. Crane, August 25, 1946
Louis C. Lawton, August 27, 1946
Christopher J. Carven, October 9, 1946
Frank S. Bailey, January 21, 1947

Remission of Dues

During this year the Board of Government granted a number of members an extension of time for payment of dues. In the case of one member, dues for the year ending March 19, 1947, have been remitted, in addition to those members in the Armed Services, numbering 31.

Exemption of Dues

Eighty-two members are now exempt from dues in accordance with By-Laws, 8, which provide 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 have been held during the year.

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

The total attendance at all meetings was 1261 persons; the largest attendance was 315 and the smallest 44. Dinners have been a feature at all the meetings and they were well attended, a total of 1067 at all dinners.

The papers and addresses given were as follows:

March 20, 1946. Annual Meeting. Address of retiring President, Carroll A. Farwell, "The Engineers Part in Community Life".

April 24, 1946. Joint Meeting with American Society of Civil Engineers, Northeastern Section. "The Proposed New Rapid Transit System of Metropolitan Boston", by Senator Arthur Coolidge.

May 15, 1946. "The Construction Program", William P. Homan, Regional Director for New England of Civilian Production Administration.

September 26, 1946. "Trend of Costs in the Construction Industry", William N. Nye, Vice-President, Turner Construction Company, New York; Mr. John Allen, Chief Engineer, U. S. Engineer Office, Boston, Mass., presented data on trends in cost of construction and dredging.

October 20, 1946. Student Night. Joint Meeting. Boston Society of Civil Engineers and American Society of Civil Engineers, and Student Chapters ASCE of Northeastern Section. "Engineering Services of the U. S. Waterways Experiment Station with Special Reference to the Mississippi Basin Model", Col. Carroll T. Newton, Corps of Engineers, Director of the U. S. Waterways Experiment Station, Vicksburg, Mississippi.

November 20, 1946. "The Foundation for the New John Hancock Building in Boston". Arthur Casagrande, Graduate School of Engineering, Harvard University; Chester N. Godfrey, Executive Partner, Cram and Ferguson, Architect Engineers.

December 18, 1946. "Sewage Treatment in New York City", Richard H. Gould, Director, Division of Engineering and Architecture, Department of Public Works, New York, N. Y.

January 22, 1947. "The Water System of the City of Philadelphia and the Proposed Supply from Upland Sources", Nathan B. Jacobs, President, Morris Knowles, Inc., Engineers, Pittsburgh, Pa.

February 26, 1947. "Maine Turnpike Project", Col. Enoch R. Needles, Consulting Engineer, Partner, Howard, Needles, Tammen and Bergendoff, New York.

Sections

Twenty-nine 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 4 meetings during the year, with an average attendance of 63. 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 74. The papers and meetings during the year are listed in the report of the Executive Committee.

Transportation Section Meetings. The Transportation Section has held 3 meetings during the year, with an average attendance of 95. The papers and meetings are listed in the report of the Executive Committee.

Hydraulics Section Meetings. The Hydraulics Section has held 4 meetings during the year, with an average attendance of 46. The papers and meetings are listed in the report of the Executive Committee.

Northeastern University Section Meetings. The Northeastern University Section held 10 meetings during the year, with an average attendance of 43. The meetings held are listed in the report of the Executive Committee.

Journal

The complete report of the Editor of the JOURNAL for the calendar year 1946 will be printed in the April, 1947, JOURNAL.

*Funds of the Society**

Permanent Fund. The Permanent Fund of the Society has a present value of about $67,200. 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 was 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 the Society; 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.

Edmund K. Turner Fund. In 1916 the Society received 1105 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 that the income from this fund accrue and build up to its $1000, and no appropriation be made this year for the purchase of books.

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.

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 $2499.11 on June 30, 1946. No award was made for the year 1946-1947.

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

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

charitable and educational purposes". The expenditure made during the year from this fund was for medals and leather boxes for medals.

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 a meeting of the Society. The present value of this fund is about $1200. The expenditure made during the year from this fund was for prizes.

Edward A. Howe Fund. This fund, a bequest of $1000, was received December 2, 1933, from the late Edward A. 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 to be kept intact, and that the income be used for the benefit of the Society or its members. The expenditure made during the year from this fund was for the purchase of new lantern, screen and speakers stand for the Society rooms.

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. No award of medal was made this year.

Clemens Herschel Awards

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. The Board voted to award a Clemens Herschel Prize to Prof. John B. Wilbur, member, for his paper on "The Action of Impulsive Loads on Elastic Structures", presented March 20, 1946, at the Annual Meeting of the Society, and published in the July, 1946, JOURNAL. Also the Board voted to award a Clemens Herschel Prize to Oscar S. Bray, for his paper on "The Mystic Cable Tunnel Design and Construction", presented at a meeting of the Designers Section held on December 12, 1945, and published in the July, 1946, JOURNAL. The prizes consisted of the following books:

"Mechanical Vibrations", by Den Hartog
"Vibration Problems in Engineering", by S. Timoshenko
"Mathematical Methods in Engineering", by Carmen Biot
"Lincoln—The Prairie Years", Vol. I and II, by Carl Sandburg
"Shotgunning the Uplands", by Ray P. Holland

Section Prize Awards

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".

Sanitary Section Prize. The Board adopted the recommendation of the Sanitary Section Prize Award Committee and voted that the Sanitary Section Prize be awarded to Allen J. Burdoin, member, for his paper on "Gas Engine Power for Sewage Treatment", presented at a meeting of the Sanitary Section, held on October 3, 1945, and published in the January, 1946, JOURNAL. The prize consisted of the following books:

"Hydraulics for Engineers", by Robert W. Angus
"Heat Transmission", by William H. McAdams
"The Theory of the Gyroscopic Compass", by A. L. Rawlings
"Fundamentals of Hydro- and Aeromechanics", by O. G. Tietjens

Designers Section Prize. The Board adopted the recommendation of the Designers Section Prize Award Committee and voted that the Designers Section Prize be awarded to Henry Brask, member, for his paper on "Clamshell Bucket Unloading Powers", presented at a meeting of the Designers Section, held on February 13, 1946, and published in the July, 1946, JOURNAL. The prize consisted of the following books:

"Rahmenformeln-Kleinlogel" (Unger) Translation Key to Ditto
"The Oceans", by Sverdrup
"Don Grafs Data Sheets", Reinold Publishing Company

Northeastern University Section Prize. The Board of Government voted on March 10, 1931, to provide for the award of a prize to a member of the Northeastern University Section.

The Board adopted the recommendation of the Committee on Awards and voted that the Northeastern University Section Prize be awarded to Richard W. Newcomb, member, for his paper on "Automatic Sprinkler Systems", presented at a meeting of the Northeastern University Student Section, held on December 4, 1946. The prize consisted of the following books:

"American Civil Engineer's Handbook", Vol. I and II, by T. Merriman and T. H. Wiggin
"Fire Insurance Underwriting", by P. B. Reed

Resolution

The Society voted to adopt a "Resolution" regarding salaries of professional engineers engaged in the service of the Commonwealth and recommended to the Joint Committee on Ways and Means of the General Court of Massachusetts that action be taken to provide for upward readjustment of the salaries of the engineering personnel employed by the Commonwealth. Action on which was taken at the January 22 and February 26, 1947, meetings of the Society.

Publication Fund

The Fund was established October 28, 1946, by the Board of Government, as a special fund to be designated "Publication Fund", for payment of reprinting "Contributions to Soil Mechanics", at a cost of $1700. This fund to consist of cash allocated temporarily from the income of investments and that repayments or reimbursements of cash from sales of said book be made from time to time into the account of the "Publication Fund", to be later transferred to the account of income from investments, the amount of said publication fund to be not in excess of $1800.

Meetings

Six of the regular meetings were held at Chipman Hall, Tremont Temple, one at Boston City Club and one at the Engineers' Club and one at the 20th Century Association.

Library

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

Committees

The usual special committees dealing with the activities and conduct of the Society have included the following: Program, Publication, Library, Hospitality, Relations of Sections to Main Society, Welfare, Investment, Subsoils of Boston, John R. Freeman, Committee on 100th Anniversary, Committee on Building Laws and Building Construction, Committee on Quarters, and the committees on the various prize awards.

The Society has cooperated with the Engineering Societies of New England, and members of the Society have served on Engineering Societies Council and 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.

GEORGE A. SAMPSON, *President*

REPORT OF THE TREASURER

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

The financial standing of the Society on March 7, 1947, at the end of the accounting period, is shown in the following tables:

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

The receipts from dues during this year amounted to $4851.00 compared with $4444.38 paid in as dues during the previous year. These receipts were $258.00 more than the average amount received from this source during the past five years. Dues of members in the Armed Forces, to the extent of $180 were remitted during the year. The payment of dues by the active members has been very satisfactory.

The income to the Current Fund has again been insufficient to meet current expenses and a transfer of $1140.25 from the income of the Permanent Fund to the Current Fund has been necessary to meet this deficit. This transfer amounts to 15% of the income to the Permanent Fund compared to a similar transfer amounting to 32% for the previous year.

The expenses of the Society have run somewhat higher than the budget estimated for the year and somewhat higher than the expenses during the preceding year. The general price rise has continued and is reflected in the cost of most phases of the activities of the Society. However, the expenses incurred by the various Sections for their meetings have been less than provided for in the budget in spite of an active program.

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

	1942-43	1943-44	1944-45	1945-46	1946-47
Receipts to Current Fund					
Dues	$4653	$4676	$4317	$4444	$4851
Other than dues	2180	3161	3518	3216	3560
Total Receipts to Current Fund	$6833	$7837	$7835	$7660	$8411
Current Fund Expenditure	8243	9246	9239	8496	9551
Deficit: Transferred from Permanent Fund	$1410	$1409	$1404	$836	$1140

The holdings of the Society in Cooperative Bank Shares were continued throughout the year. The running shares were maintained and payments were made monthly, thereby increasing the value of all our holdings from $12,068.89 on March 8, 1946, to $12,613.26 on March 7, 1947.

Refunding of bond issues were few during the year and only the following changes were made in the security holdings of the Society:

1000 Penn. Central Light and Power, Nov. 1, 1977, called @ 104, Nov. 1, 1946.
225 United States Trust Co. Conv. pfd. called as of July 1, 1946, for conversion to 225 shares of Common Stock.
1000 Am. Tel. and Tel. Co., Dec. 15, 1961, purchased Nov. 21, 1946.
4000 U. S. Savings Bonds, series G, May, 1958, purchased May 22, 1946.

Rights were issued to holders of American Telephone and Telegraph Company stock towards the purchase of an issue of American Telephone and Telegraph Company Bonds, due December 15, 1961, and the purchase listed above was made through this arrangement.

The Board of Government voted to establish a special fund to be designated "Publication Fund", for payment of reprinting "Contributions to Soil Mechanics", since the previous issue was sold out and the demand continues. Fifteen hundred books were printed and as of March 7, 1947, 273 had been sold. Expense to the fund amounted to $1767.96 and receipts totalled $576.65.

The Boston Safe Deposit and Trust Company has continued to act as Investment Counsel for the Society throughout the year and they were consulted in connection with all purchases and sales of securities.

The total book value of all securities, plus cash on hand now stands at $106,391.88 an increase of $3,056.00 in assets during the year.

The following table shows the comparative book values of the two principal funds at the close of the last five years and the ratio of market value to book value.

	Mar. 6, 1943	Mar. 6, 1944	Mar. 8, 1945	Mar. 8, 1946	Mar. 7, 1947
Permanent Fund	$62,283	$62,546	$63,690	$65,618	$67,228
John R. Freeman Fund	26,862	27,470	28,497	29,654	30,803
Market Value in percent of book value	88.57%	96.47%	101.7%	114%	103.5%

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, in order to meet current expenses. The value of the Freeman Fund depends largely upon the expenditures made from the fund during the year and as no expenditures were made during the past year the only charge to the fund has been the allocation of book loss incurred through the sale of depreciated securities, amounting to $3.75 as shown in Table 1.

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

	Mar. 6, 1943	Mar. 6, 1944	Mar. 8, 1945	Mar. 8, 1946	Mar. 7, 1947
Bonds	$38,670.49	$38,763.93	$35,816.10	$34,318.15	$38,340.01
Cooperative Banks	12,392.68	10,942.02	11,535.19	12,068.89	12,613.26
Stocks	43,967.17	45,186.63	50,708.44	51,809.15	51,809.15
Cash	2,031.39	2,981.57	2,121.57	5,139.69	1,929.46
	$97,061.73	$97,874.15	$100,181.30	$103,335.88	$104,691.88
Publication Fund					1,700.00
					$106,391.88

The Treasurer's cash balance $1929.46 includes $40.00 withholding taxes of the office secretary for the months of January and February, 1947, which is payable to the Collector of Internal Revenue in April, 1947. The Secretary's "change fund", $30, however, is not included in the cash balance shown above.

Respectfully submitted,

CHESTER J. GINDER, *Treasurer*

TABLE 1—DISTRIBUTION OF FUNDS—RECEIPTS AND EXPENDITURES

	Book Value March 8 1946	Interest and Dividends Cash	Interest and Dividends Credit	Net Profit or Loss at Sale or Maturity +	Net Profit or Loss at Sale or Maturity —	Transfer of Funds Purchased +	Transfer of Funds Sold —	Book Value March 7 1947
Bonds	$34,318.15	$1,041.66	$ 60.00		$12.89	$5,014.75	$1,052.89	$38,340.01
Cooperative Banks	12,068.89	65.00	184.37			360.00		12,613.26
Stocks	51,809.15	2,606.15				4,837.50	4,837.50	51,809.15
Cash available for Investment	3,639.69						3,718.92	—79.23
Publication Fund Loan						1,700.00		1,700.00
Total (except Current Fund)	$101,835.88	$3,712.81	$244.37		$12.89	$11,912.25	$9,609.31	$104,383.19
	Book Value March 8 1946	Allocation of the above Income and Profit 3.89%	Loss			Misc. Receipts	Misc. Expenditures	Book Value March 7 1947
Permanent Fund	$ 65,618.09	$2,549.81	$ 8.32			$ 209.00	$1,140.25	$67,228.33
John R. Freeman Fund	29,654.37	1,152.32	3.75					30,802.94
Edmund K. Turner Fund	977.73	37.99	.12					1,015.60
Desmond FitzGerald Fund	2,010.29	78.12	.25				88.40	1,999.76
Alexis H. French Fund	1,041.83	40.48	.13				9.25	1,072.93
Clemens Herschel Fund	1,242.86	48.30	.16				42.43	1,248.57
Edward A. Howe Fund	1,290.71	50.16	.16				325.65	1,015.06
	$101,835.88	$3,957.18	$12.89			$ 209.00	$1,605.98	$104,383.19
Publication Fund						2,276.65	1,767.96	†508.69
Current Fund	1,500.00					*9,551.50	9,551.50	1,500.00
Totals	$103,335.88	$3,957.18	$12.89			$12,037.15	$12,925.44	$106,391.88

Secretary's change fund of $30.00 should be added to show total assets.
*Includes transfer of $1,140.25 from income of Permanent Fund to Current Fund.
†This amount plus the unsold books represents the value of this fund.
Of the 1500 copies published 273 have been sold and 1227 were on hand March 7, 1947.

TABLE 2—RECORD OF INVESTMENTS

	Date of Maturity or Classification	Fixed or Current Interest Rate	During the Year March 8, 1946 to March 7, 1947				March 7, 1947		
			Interest Received	Additional Amount Invested	*Sold or Matured* Cost	*Sold or Matured* Profit + (or loss —)	Par Value	Book Value	Market Value
BONDS									
American Telephone & Telegraph Co.	Dec. 15, 1961	2¾%	....	$1,014.75	....	....	$1,000.00	$1,014.75	$1,138.75
Canadian Pacific R.R.	July 2, 1949	4%	169.16	....	....	....	5,000.00	5,342.50	5,000.00
Penn. Central Light & Power Co.	Nov. 1, 1977	4½%	45.00	....	1,052.89	12.89—	....	....	....
The Pennsylvania Railroad Company	June 1, 1965	4½%	45.00	....	....	....	1,000.00	1,017.74	1,110.00
Puget Sound Power & Light Co.	Dec. 1, 1972	4¼%	42.50	....	....	....	1,000.00	1,058.44	1,068.75
Southern Pacific Oregon	Mar. 1, 1977	4½%	180.00	....	....	....	4,000.00	4,191.30	4,065.00
The Toledo Edison Co.	July 1, 1968	3½%	70.00	....	....	....	2,000.00	2,092.50	2,095.00
Western Maryland R.R. Co.	Oct. 1, 1952	4%	40.00	....	....	....	1,000.00	982.78	1,052.50
United States Savings Bonds, Series D	Jan. 1, 1950	....	60.00	....	....	....	3,000.00	2,640.00	2,640.00
United States Savings Bonds, Series G	June 1, 1953	2½%	200.00	....	....	....	8,000.00	8,000.00	8,000.00
United States Bonds, Series G	July 1, 1954	2½%	175.00	....	....	....	7,000.00	7,000.00	7,000.00
United States Savings Bonds, Series G	Nov. 1, 1956	2½%	25.00	....	....	....	1,000.00	1,000.00	1,000.00
United States Savings Bonds, Series G	May 1, 1958	2½%	50.00	4,000.00	....	....	4,000.00	4,000.00	4,000.00
TOTALS			$1.101.66	$5,014.75	$1,052.89	$12.89—	$38,000.00	$38,340.01	$38,170.00

TABLE 2—RECORD OF INVESTMENTS—*Continued*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 8, 1946 to March 7, 1947				March 7, 1947		
			Dividends Received	Additional Amount Invested	*Sold or Matured* Amount Received	Profit + (or loss —)	Number of Shares	Book Value	Market Value
CO-OPERATIVE BANKS									
Codman Co-Operative Bank	Matured Certificate	2¼%	$ 45.00	....	....	....	10	$ 2,000.00	$ 2,000.00
Suffolk Co-Operative Federal Savings & Loan Assoc.	Matured Certificate	2%	20.00	....	....	....	5	1,000.00	1,000.00
Suffolk Co-Operative Federal Savings & Loan Assoc.	Series 134	....	184.37	$360.00	....	....	30	9,613.26	9,613.26
TOTALS			$249.37	$360.00				$12,613.26	$12,613.26

TABLE 2—RECORD OF INVESTMENTS—*Continued*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 8, 1946 to March 7, 1947: Dividends Received	Additional Amount Invested	*Sold or Matured*: Cost	*Sold or Matured*: Profit + (or loss —)	March 7, 1947: Number of Shares	Book Value	Market Value
STOCKS									
American Tel. & Tel. Co.	Common	$9.00	$468.00	....	....	....	52	$ 6,189.04	$ 8,723.00
Bankers Trust Co., N. Y.	Common	1.80	77.40*	....	....	....	36	1,590.00	1,575.00
Central Hanover Bank & Trust Co. of N. Y.	Common	4.00	120.00	....	....	....	30	3,210.00	3,030.00
Commonwealth & Southern Corp.	Cum. Pfd.	....	86.00	....	....	....	8	....	970.00
Commonwealth & Southern Corp.	Common	....	....	....	....	....	25	1,019.89	81.25
Commonwealth & Southern Corp.	Opt. Warrants	....	....	....	....	....	12	....	1.50
Consolidated Natural Gas Company	Capital	2.00	4.00	....	....	....	2	49.87	98.25
Consolidated Edison (Gas) Co. of N. Y.	Common	1.60	32.00	....	....	....	20	1,906.50	557.50
Continental Insurance Co.	Capital	2.00	50.00	....	....	....	25	1,206.44	1,275.00
Erie Railway 5%	Pref.	5.00	75.00	....	....	....	15	1,133.05	926.25
General Electric Co. of N. Y.	Common	1.60	80.00	....	....	....	50	2,341.47	1,843.75
Great Northern Railway	Pref.	3.00	45.00	....	....	....	15	778.67	645.00
Hartford Fire Insurance Co.	Common	2.50	25.00	....	....	....	10	761.25	1,090.00
Minnesota Power & Light Co., Minn.	Pref.	5.00	50.00	....	....	....	10	882.00	1,067.50
National Dairy Products Corp.	Common	1.65	82.50	....	....	....	50	1,154.74	1,562.50
National Fire Insurance Co. of Hartford	Common	2.00	40.00	....	....	....	20	1,240.00	1,050.00
New England Power Assoc.	Pref.	6.00	120.00	....	....	....	20	1,815.00	1,720.00
North American Trust Shares	July 15, 1955	14.6¢	219.00	....	....	....	1500	5,342.00	5,055.00

TABLE 2—RECORD OF INVESTMENTS—*Continued*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 8, 1946 to March 7, 1947				March 7, 1947		
			Dividends Received	Additional Amount Invested	*Sold or Matured* Cost	Profit + (or loss —)	Number of Shares	Book Value	Market Value
STOCKS									
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	$1.50	$ 90.00	....	....	....	60	....	$ 3,262.50
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	1.37	27.52	....	....	....	20	$ 1,922.02	
Pacific Gas & Elec. Co.	Common	2.00	128.00	....	....	....	64	1,808.79	2,624.00
Radio Corp. of America	1st Pfd.	3.50	70.00	....	....	....	20	1,720.75	1,580.00
Southern California Edison Co. Ltd.	Cum. Orig. Pfd.	1.50	60.00	....	....	....	40	1,161.22	1,750.00
Southern California Edison	Common	1.50	30.00	....	....	....	20	539.75	650.00
Southern Railway	Pref.	5.00	75.00	....	....	....	15	1,136.80	1,072.50
Standard Oil Co. of N. J.	Capital	3.08	61.60	....	....	....	20	1,011.10	1,300.00
Tampa Electric Co.	Common	1.60	60.00*	....	....	....	30	1,151.25	982.50
Timken Roller Bearing Co.	Common	1.87	28.13	....	....	....	15	1,018.97	716.25
Trimount Dredging Co.	Pref.	....	....	....	....	....	2	....	....
Union Carbide & Carbon	Capital	3.00	90.00	....	....	....	30	2,407.79	2,917.50
Union Pacific Railroad	Common	6.00	132.00	....	....	....	22	2,473.29	2,761.00
United States Trust Co. of Boston	Conv. Pref.	.80	90.00	....	4,837.50	....	..	....	....
United States Trust Co.	Common	.80	90.00	4,837.50	....	....	225	4,837.50	4,331.25
TOTALS			$2,606.15	$4,837.50	$4,837.50			$51,809.15	$55,219.00

*Banker's Trust Co, dividend of $12.60 and Tampa Electric Co., dividend of $12.00 were in transit at close of previous year and are included in this period.

REPORT OF THE SECRETARY

Boston, Mass., March 7, 1947.

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 19, 1947
CURRENT FUND ACCOUNT

	Account Number	Expenditures	Receipts
Office			
Secretary, salary and expense	(1)	$ 240.00	
Stationery, printing and postage	(2)	326.23	
Incidentals and Petty Cash	(3)	131.99	
Insurance and Treasurer's Bond	(4)	38.80	
Safety Deposit Box	(5)	12.00	
Quarters, rent, light, telephone	(7)	1,762.58	$630.00
Office—clerical	(8)	1,770.00	
Auditors for 1946 accounts and Investment Service	(9)	250.00	
Meetings			
Rent of Halls	(11)	231.00	
Stationery, printing	(12)	36.10	
Social Activities	(13)	1,761.96	1,551.80
Steropticon and reporting	(14, 15)	25.00	
Annual Meeting (March 1946)	(16)	94.40	
Sections			
Sanitary Section	(21)	12.00	
Designers Section	(22)	41.00	
Transportation Section	(23)	2.00	
Northeastern Univ. Section	(24)	15.00	
Hydraulics Section	(25)	19.05	
Journal			
Editor's salary and expense	(31)	308.00	
Printing and postage	(32)	1,634.68	
Reprints	(33)	50.00	
Advertising	(34)		823.00
Sale of Journals and reprints	(35, 36)		494.75
Library			
Books and expense	(41)	25.00	
Periodicals	(43)	100.00	
Binding	(44)	49.00	
Fines on Overdue Books & Misc.	(54, 45)	4.00	
Dues to Eng. Societies of New England	(59)	559.07	
Dues from BSCE Members	(70)		4,851.00
Badges for Members	(51)	37.80	37.80

	Account Number	Expenditures	Receipts
Binding Journals for members	(52)	14.40	17.14
Bank Charges	(53)	.44	
Transfer Income Permanent Fund to Current Fund			1,140.25
		$9,551.50	$9,551.50

Payments to Permanent Fund

Entrance Fees for new members	$199.00
Payments allocated from current year's dues of members who transferred to higher grade during previous year, according to By-Laws, Paragraph 8.	10.00
Total to Permanent Fund	$209.00

17 new members; 13 students; 19 juniors transferred to members; 3 students transferred to juniors, 1 student transferred to member.

Publication Fund—authorized by Board of Government on October 28, 1946, to provide for the cost of printing 1500 reprints of "Contributions to Soil Mechanics". Total volumes sold to date 273. The receipts from sales to be credited to this fund to date $576.65.

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 dinners.

Respectfully submitted,

EVERETT N. HUTCHINS, *Secretary*

REPORT OF THE AUDITING COMMITTEE

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

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 Accountant.

FRANCIS H. KINGSBURY

DONALD W. TAYLOR

Auditing Committee of the Directors of the Boston Society of Civil Engineers

March 15, 1947.

MR. FRANCIS H. KINGSBURY
Chairman of the Auditing Committee
Boston Society of Civil Engineers

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 7, 1947, and report as follows.

All changes in securities owned were found properly recorded in the accounts. All receipts of income, including entrance fees, as recorded in the records of the Secretary, also interest and dividends were found correctly recorded in the Treasurer's accounts and to have been deposited in the bank.

Cooperative Bank earnings were verified and found correct.

All paid bills were approved by the President and Secretary and settlement substantiated by paid checks returned by the bank.

Withheld taxes for January and February amount to $40 and will be included in the quarterly payment to the Collector of Internal Revenue due in April. In accordance with past practice the Secretary's change fund, $30, is not included in the assets reported by the Treasurer.

The inception of the Publication Fund, $1700.00, introduces an element of tangible assets whereas formerly your investments have been of the intangible class. The costs and expenses of publication exceeded the total fund by $67.96 but receipts from sales amounted to $576.65. This gave a net recovery to the fund of $508.69. The remaining balance of the fund, $1191.31, would be represented by the books on hand.

A verified copy of the Treasurer's report is attached hereto and summaries of his ledger accounts are shown in detail. I found the records for the fiscal year ended March 7th, 1947, in good condition and, in my opinion, they are correct.

Respectfully submitted,

WM. J. HYDE, *Certified Public Accountant*

REPORT OF THE EDITOR

February 10, 1947

To the Board of Government
Boston Society of Civil Engineers:

The JOURNAL for the calendar year 1946 (Volume XXXIII) 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 1946 there have been published ten papers presented at meetings of the Society and Sections. Also there was printed in the April issue the Constitution and By-Laws of the Society, incorporating amendments to date, and the Rules relating to all prizes and a complete list of prizes awarded to date. The Table of Contents and Index for the year are included in the October, 1946, issue.

The four issues of the JOURNAL contained 246 pages of papers, discussion, and proceedings, 6 pages of Index, and 36 pages of advertising, a total of 292 pages. An average of 1100 copies per issue were printed. The net cost was $801.28 as compared with $319.60 for the preceding year.

The cost of printing the JOURNAL was as follows: :

Expenditures		
Composition and printing	$1,362.18	
Cuts	356.95	
Wrapping, mailing and postage	73.00	
Editor	300.00	
Copyright	8.00	
		$2,100.13
Receipts		
Receipts from sale of JOURNALS and reprints	$ 475.85	
Receipts from Advertising	823.00	
		1,298.85
Net cost of JOURNAL to be paid from Current Fund		$ 801.28

Respectfully submitted,

EVERETT N. HUTCHINS, *Editor*

REPORT OF THE COMMITTEE ON WELFARE

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

Engineering employment was very good during the first part of the year and moderately good during the latter part. No matters relating to welfare assistance for our members have come to the attention of the Welfare Committee, and in consequence no meetings of the Committee have been held during the year.

The Emergency Planning and Research Bureau, Inc., 101 Tremont Street, Boston, continues to serve as the official local agency for the placement of engineering and architectural employees.

Respectfully submitted,

R. W. HORNE, *Chairman*

REPORT OF THE HOSPITALITY COMMITTEE

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

The Hospitality Committee submits the following report for the year 1946 1947.

Seven regular meetings, a Student Night meeting and an Annual Dinner were held during the year. The Annual Meeting was held at the Boston City Club, the April meeting was at the Engineer's Club, the May meeting at the 20th Century Association and all other meetings were held in Chipman Hall at Tremont Temple.

The attendance at the Annual Dinner in March was 198, or 23 more than at the previous Annual Meeting. The Student Night Meeting was held in Chipman Hall at which the attendance was 299. This meeting was also a joint meeting with the American Society of Civil Engineers, Northeastern Section The attendance at this meeting was about double the attendance at the previous year's Student Night Meeting.

The total attendance at the seven regular meetings was 570, an average of 81 persons per meeting. This average is 24 more than for the previous year An average of 25 additional persons attended the meeting following the supper.

The summary of meetings and attendance follows:

Date	Speaker	Place	Attendance at Dinner	Attendance at Meetings
3-20-46	Carroll A. Farwell	Boston City Club	198	198
4-24-46	Senator Arthur Coolidge	Engineers' Club	44	44
5-15-46	William P. Homans	20th Century Assoc.	44	44
9-25-46	William N. Nye	Chipman Hall	74	90
10-28-46	Col. Carroll T. Newton	Chipman Hall	299	315
11-20-46	H. M. Parsons	Chipman Hall	137	210
12-18-46	Richard H. Gould	Chipman Hall	85	110
1-22-46	Nathan Jacobs	Chipman Hall	73	82
2-26-47	Enoch Needles	Chipman Hall	113	168
			1067	1261

The average attendance at all nine meetings was 119, thirty-eight more than for the year 1945-1946.

Respectfully submitted,

JOHN H. HARDING, *Chairman*

REPORT OF THE LIBRARY COMMITTEE

Boston, Mass., March 19, 1947

To the Board of Government
Boston Society of Civil Engineers:

The Library Committee has been very active during the past year and six meetings of the committee were held. The Committee concentrated its efforts in formulating a policy for the library as a first step in correcting the present disordered and inefficient condition of the library.

At the request of the Committee each of the various Sections appointed members to serve as advisors to the Committee regarding any material relating to the respective sections. The following members were appointed and have been most cooperative:

Sanitary Section—William E. Stanley, Charles O. Baird, Jack McKee.
Designers Section—Arthur E. Harding, Oliver G. Julian.
Hydraulics Section—Allen J. Burdoin, Byron O. McCoy, Leslie J. Hooper.
Transportation Section—George W. Hankinson.

Similarly the ESNE was invited to appoint representatives to discuss with the Committee the disposition of material not of a Civil Engineering nature. The following were appointed:

Arthur G. Bousquet .... I.R.E.
Joseph H. Keenan .... A.S.M.E.
Earl D. Benson .... I.E.S.
Alvin H. Howell .... A.I.E.E.

A statement containing a survey of current conditions and problems at the library, together with specific recommendations as to future policy, was drawn up and circulated among the Section Advisory Committees. Upon receipt of the comments of the various Advisory Committee members, several minor revisions were made in the preliminary recommendations. The revised statement and recommendations is enclosed with the report as Appendix "A". The Committee requests that the Board of Government give these recommendations consideration at its earliest convenience so that the rehabilitation of the library may soon get under way.

Upon the suggestion of President Sampson each of the member societies of the E.S.N.E. was approached by letter to determine its probable interest in the B.S.C.E. Library. A transcript of this letter is enclosed as Appendix "B". To date only a limited number of replies have been received and all of these have indicated no interest in the B.S.C.E. Library.

Members of the Committee, working evenings, attempted to improve the appearance of the stacks. Most of the unbound material in the stacks in the front room was removed and placed in the metal stacks in the back room. Certain old files of periodicals and duplicate copies of other material were also removed to the metal stacks to allow room for expansion in the front room files.

Certain material said to be previously authorized for discard has been stacked in one corner of the rear room for disposal. This material consists principally of bound reports of the Chief of Engineers, U. S. Army. Also piled with this material are unbound copies between the years 1932 and 1940 of periodicals, which the Committee in Appendix "A" has recommended be not kept in permanent files. In addition are a number of duplicate bound copies of Transactions of A.S.C.E. and of predecessors of Engineering News Record. The two sets of ancient encyclopedias have also been stacked with this material. The Committee requests that the Board, after it has considered its recommendations of policy, express its desires as to the disposal of this material. An extended survey has disclosed no organization or persons who desires the material.

The Committee has segregated the old books in the metal stacks into topical subjects. The various Advisory Committees are being furnished lists containing the names of books of interest to their particular sections for study and recommendations. This segregation and study is also a possible first step in the setting up of an Historical Collection.

Because of the increased cost of binding periodicals which depleted the available funds and because of lack of policy, only the following books were purchased during this fiscal year:

"Railway Engineering & Maintenance Cyclopedia" 1945.
"Boston Building Code".
"Bests Safety Directory".

The following books were denoted to the Library as gifts of the author:

"Design of Reinforced Concrete Structures", by Dean Peabody, Jr.
"Rock Defects and Loads on Tunnel Supports", by Karl Terzaghi.

During the past year 115 books were loaned out. $1.76 was collected in fines.

Respectfully submitted,

ATHOLE B. EDWARDS, *Chairman*

APPENDIX "A"

The Library Committee is concerned over the dilapidated condition of the Society Library. Since the days of the depression the condition of the Library has deteriorated steadily in spite of sincere efforts on the part of past committees to halt this trend. With the passing of the wartime emergency it is hoped that a period of growth and increased interest is at hand for the Society. If the library is to fulfill its part in the future of the Society an adequate and workable policy for its operation and development must be formulated. In the following pages the committee attempts to devise such a policy.

A matter of first importance is the use made of the present library facilities. Table I was compiled from figures given in the annual reports of the Society

TABLE I

Year	Total Membership	No. Books Loaned During Year	Remarks
1913-14	837	309	
1914-15	928	296	
1915-16	999	335	
1916-17	966	386	
1917-18	917	266	
1918-19	888	283	
1919-20	881	260	
1920-21	900	308	
1921-22	902	284	13 people per day
1922-23	918	243	use library
1923-24	936	249	
1924-25	952	330	Library kept open
1925-26	958	411	Saturday except
1926-27	969	389	during summer
1927-28	1030	382	
1928-29	1043	377	
1929-30	1065	325	
1930-31	1048	311	
1931-32	973	291	
1932-33	986	411	
1933-34	962	188	
1934-35	938	—	
1935-36	787	120	
1936-37	753	125	
1937-38	715	175	
1938-39	694	157	
1939-40	750	130	
1940-41	745	128	
1941-42	749	130	
1942-43	712	122	
1943-44	694	132	
1944-45	695	114	
1945-46	704	95	
1946-47	—	115	Up to Feb. 27, 1947

TABLE II—AVAILABILITY OF PERIODICALS CURRENTLY RECEIVED AT BSCE LIBRARY

Periodicals	How Obtained by BSCE	BSCE (Bound copies) From	BSCE (Bound copies) To	Boston Public Library From	Boston Public Library To	Com. of Mass. Library From	Com. of Mass. Library To	M.I.T. From	M.I.T. To	Harvard From	Harvard To	Tufts From	Tufts To	Northeastern From	Northeastern To
Periodicals Received by B.S.C.E.															
Am. Soc. of C.E. Trans.	Subs.	1874	Date	1867	Date	1909	1928	1867	Date	1867	Date	1867	Date	1872	Date
Am. Soc. of C.E. Proc.	Exch.	1873	1926	1922[2]	Date	1915[3]	1917	1873	Date	1873	Date	1896	Date	Current	
Architectural Record	Subs.	—	—	1891	Date			1891	Date			1919	Date	1927	Date
Roads & Bridges (Formerly Canadian Engr.)	Subs.	1895	Date					1942	Date					Current	
Water & Sewage (Formerly Canadian Engr.)	Subs.	1895	Date					1942	Date					Current	
Civil Engineering	Subs.	1930	Date	1940	Date[5]	1930	Date[4]	1930	Date	1930	Date	1931	Date	1930	Date
Electrical World	Subs.	1908	1940[1]	1883	Date			1883	Date	1884	Date	1833	Date	1887	Date
Power	Subs.	1916	1932	1892	Date			1892	Date	1884	Date	1914	Date		
Eng. News Record	Subs.	1878	Date	1877	Date	1885	Date[4]	1874	Date	1877	Date	1885[11]	Date	1887	Date
Industrial Arts Index	Subs.	1913	Date	1913	Date	1924	Date	1913	Date	Current		1913	Date	1920	Date
Iron Age	Subs.	1920	1934	1883	Date			1873	Date			1933	Date[12]	Current	
Public Works	Subs.	1903	Date	1908	Date	1914	Date[5]	1906	Date	1941	Date	1937	Date	1934	Date
Railway Age	Subs.	1876	1934	1871	Date			1872	Date			1918[13]	Date		
Roads & Streets	Subs.	—	—	1926	Date			1926	Date	1923	Date	1922	Date	1926	Date
Water & Sewage Works	Subs.	1909	Date	1892	Date	1930	Date[4]	1890	Date	1927	Date	1925	Date	1930	Date
A.W.W.A. Journal	Exch.	1890	Date	1914	Date	1881	1913	1881	Date	1914	Date	1904	1917		
N.E.W.W.A. Journal	Exch.	1888	Date	1886	Date	1886	Date	1886	Date	1886	Date	1902	Date	1935	Date
The Engineer (British)	Subs.	1864	1932	1856	Date			1856	Date	1856	Date				
The Military Engineer	Exch.	1910	1930	1909	Date	1930	1934	1909	Date	1920[10]	Date	1926	1932		
The Wisconsin Engr.	Exch.	—	—					1922[7]	1933						
A.S.T.M. Proc.	Exch.	1904	1940	1899	Date			1934	Date	1898	Date	1939	Date	1925	Date
Tech. Eng. News	Exch.	—	—					1920	Date						
Technology Review	Exch.	—	—	1899	Date	1899	Date	1899	Date	1937	1939	1899[14]	Date	Current	
Jr. Worcester Poly. Inst.	Exch.	—	—					1897	1931						
Sewage Works Jr.	Exch.	1939	Date					1928	Date	1928	Date	1939	Date	1937	Date
Jr. Eng. Inst. of Canada	Exch.	—	—	1919	Date			1925	Date	1943	Date				
Jr. Franklin Inst.	Exch.	1826	1932	1826	Date	1836[6]	Date	1826	Date	1826	Date	1870	Date	1930[17]	Date
Jr. Inst. of Civil Eng. (British)	Exch.	1863	1940	1935	Date										
Compressed Air Mag.	Exch.	—	—					1837	Date	1837	Date	1903	1916		
New England Construction	Exch.			Current				1896	Date	1926	Date	1926	Date	Current	
				5 yrs.				1936	Date					Current	
Public Health Abstracts	Exch.	—	—												
N.E. Road Builders Assn.	Exch.			Current				1929	Date	1921	Date				
				2 yrs.											
The Baltimore Eng.	Exch.	—	—												
Indust. Standards (ASA)	Exch.			1930	Date			1932	Date	1930	Date	1936	Date		
Milwaukee Eng.	Exch.	—	—												
Proc. La. Eng. Soc.	Exch.	—	—												
Colorado Eng.	Exch.	—	—					1922[9]	Date						
N.E.R.R. Club	Exch.	—	—					1894	Date						
The American Engr.	Exch.	—	—					1887[10]	1911						

TABLE II—*continued*

Periodicals	How Obtained by BSCE	BSCE (Bound copies) From	BSCE (Bound copies) To	Boston Public Library From	Boston Public Library To	Com. of Mass. Library From	Com. of Mass. Library To	M.I.T. From	M.I.T. To	Harvard From	Harvard To	Tufts From	Tufts To	Northeastern From	Northeastern To
Jr. Municipal Eng.	Exch.	—	—					1915	Date						
Constr. & Eng. Monthly	Exch.	—	—					1933	1934					Current	
The Eng. Foundation	Exch.			Odd Vols.				1931	Date			1922	Date[13]		
Jr. Western Soc. Eng.	Exch.	1896	1917	1896	1934			1896	Date			1900	1935		
Bull. Minn. Fed. of Eng. Soc.	Exch.							1916	Date						
Wood Preserving News	Exch.			Current				1923	Date	1923	Date	1940	Date[13]		
Bell System Tech. Jr.	Exch.			1923	Date			1922	Date	1922	Date	1922	Date[12]	Current	
Periodicals Received by E.S.N.E.															
A.S.M.E. Trans.		1880	Date	1880	Date			1880	Date	Complete		1909	Date	1900[17]	Date
A.I.E.E.		1896	Date	1911	Date			1884	Date	Complete		1891	Date	1891	Date
A.I. Mining & Met. Trans.		1871	1925	1871	1934			1871	Date	1929	Date	1915	1916		
Jr. Am. Welding Soc.				1922	Date			1922	1936	1922	Date			Current	
Proc. Inst. Radio Eng.				1913	Date			1913	Date			1916	Date	1929	Date
Mech. Eng.				1913	Date			1906	Date	1923	Date	1924	Date	1920	Date
Illuminating Eng.				1907	Date			1906	Date	1906	Date	1906	Date	1908	1913
Contact								Current							
Gen. Elec. Review				1915	Date			1903	Date	1910	Date	1907	Date	1920	Date
Edison Elec. Inst. Bull.				1939	Date					1940	Date				
Boston Business				1909	Date	1929	Date							Current	

[1]Bound copies received as gift.
[2]Also 1873-76, 1880-1910, 1912, 1914.
[3]1896-1906, 1912-1913.
[4]Unbound, incomplete.
[5]Incomplete.
[6]Also 1830-1831, 1834, 1836.
[7]Also Vols. 1, 6 (Vol. 26—1922).
[8]Also Vols. 1-4, 12, 14 (Vol. 18—1922).
[9]Also 1838, 1943, 1848.
[10]Also 1909-1917.
[11]1916 missing.
[12]Unbound.
[13]1938 missing.
[14]Unbound 1929-1931 missing.
[15]Also 1862-1881.
[16]Unbound 1935 missing.
[17]1940 missing.
[19]Also 1886-1889, 1897-1898.

published in the JOURNAL and shows the comparative membership of the Society and the books borrowed from the library during past years.

Commencing in 1933 the number of persons borrowing books from the library took a sharp drop from 411 in the preceding year to 188 in that year. The decline has been fairly steady ever since with an all time low of 114 occurring during 1944-45.

A count of the users of the library from December 12, 1946, to January 8, 1947, showed that an average of 3 persons per day used the facilities.

There are several reasons for this decline but perhaps the most important single reason is that in Greater Boston there are six other libraries with important civil engineering collections, three of which are more extensive than the Society Library. These libraries are as follows:

Boston Public Library
M.I.T. Library
Harvard Graduate School of Engineering Library
Tufts College Library
Commonwealth of Massachusetts Library
Northeastern University Library

Table II lists the periodicals currently received at the B.S.C.E. Library and shows which of these are received and kept on file at the six libraries listed above.

Other contributing causes include the following:

1. The Society rooms are open from 9:00 to 5:00 P.M., Monday through Friday. In general these hours preclude the use of the library except by those engaged in paid research or who can afford the time during working hours.
2. The practice of poorly paid part time librarians has resulted in the material getting in such poor order and so dirty that finding certain references is a discouraging task.
3. Since 1932 the number of periodicals bound has been greatly reduced, thus the periodical file which is a major feature of the library has decreased in value.
4. Many of the larger engineering organizations have adequate libraries of their own.

The committee feels that there are four advantages to justify the maintenance of a Society Library.

1. As a convenience to engineers located in downtown Boston.
2. The books in the society library are available for browsing, and bound volumes of periodicals may be taken from the rooms by responsible persons. These privileges are not generally available at other libraries.
3. The library adds prestige to the society quarters and makes a convenient reference for writings and works of local engineers.
4. The society can prepare collections on certain subjects of primary interest from time to time as has been done in the past.

In the present quarters except for certain unbound periodicals, space is not at the moment too critical. In considering new quarters for the society definite consideration should be given to the benefits derived from the library on the basis of area required since the yearly cost of that area will constitute an expenditure of society income. It would not seem a justifiable expenditure of the society's funds to rent space to provide storage for a lot of dusty, obsolete paper. It is also questionable how much the society is justified in spending to bind periodicals which have only a current interest and which are available elsewhere in the city.

Members of the committee have undertaken to renovate portions of the library during spare time in the evening. The results of this work while helpful have been discouragingly meagre and indicate that this is not the proper way to handle this task. The difficulties encountered were as follows:

1. The task is exceedingly dirty.
2. The Society rooms are in use so many evenings during the week that it is difficult to find available time convenient to the committee members to do the work.
3. The amount of work involved is so great as to require more time than most members are free to devote to it.

The committee makes the following recommendations which as a whole constitute a policy which should place the library in a useful and efficient position:

1. Hire a competent librarian on a part time basis to renovate the library, this librarian to be assisted to the fullest extent possible by the office secretary. If additional help is needed to clean books etc., employ students on a part time basis or if found economical hire a professional cleaning service.
2. Bind all unbound material which is to be a permanent part of the library. Unbound material on the shelves is hard to keep clean, is easily lost and deteriorates rapidly.
3. The following policy regarding periodicals be adopted:
   a) That only the publications of Engineering Societies listed in Table III be bound and kept in permanent files. This table indicates how much of this material is now available.
   b) That the publications of the Engineering Societies listed in Table IV be kept unbound and for one year only. These publications are now received in exchange for the B.S.C.E. Journal.

TABLE III—PUBLICATIONS OF ENGINEERING SOCIETIES TO BE KEPT BOUND IN PERMANENT FILES

Publication	Present Available Bound	Present Available Unbound	Recommended Period to be Covered	Yearly Cost Sub-scription	Yearly Cost Bind-ing
B.S.C.E. Jour.	1914 to date	—	1914 to date		$2.40
A.S.C.E. Trans.	1874 to date	—	1874 to date	$4.00	2.00
A.S.C.E. Proc.	1874 to 1926	—	1874 to 1926 (current 5 yrs. unbound)	Exchange	3.50
N.E.W.W.A. Jour.	1888 to date		1888 to date	Exchange	2.60
A.W.W.A. Jour.	1890 to date		1890 to date	Exchange	3.50
Sewage Works Jour.	1939 to date		1939 to date	Exchange	3.00
Eng. Inst. of Canada Jour.		1919 to date	1919 to date	Exchange	4.50
Inst. of Civil Engr. Jour. (British)	1863 to 1940	1940 to date	1863 to date	Exchange	3.00
A.S.T.M. Proc.	1904 to 1940		1904 to date	—	Rec'd Bound
A.S.M.E. Trans.	1880 to date		1880 to date	Gift of ESNE	Rec'd Bound
A.I.E.E. Trans.	1896 to date		1896 to date	Gift of ESNE	Rec'd Bound
Jour. of Western Soc. of Engrs.	1896 to 1917	1918 to date	1896 to date	Exchange	3.00
Jour. of Franklin Inst.	1826 to 1932	1933 to date	1826 to date	Excnange	3.00

TABLE IV—PUBLICATIONS OF ENGINEERING SOCIETIES TO BE KEPT UNBOUND FOR ONE YEAR ONLY

The Military Engineer
The Wisconsin Engineer
Journal of Worcester Polytechnic Institute
New England Road Builders Assoc.
The Baltimore Engineer
Milwaukee Engineer
Proceedings of Louisiana Engineering Society
Colorado Engineer
New England Railroad Club
Journal of Municipal Engineers
Bulletin of Minnesota Federation of Engineering Societies

TABLE V—PUBLICATIONS OF ENGINEERING SOCIETIES TO BE DISCARDED

Publication	Bound Copies	Unbound Copies
Proc. of Western Soc. of Engr.	1880-1881	
Proc. of Engr. Soc. of Western Penn.	1879-1918	1919 to 1932
Bull. Am. Inst. of Mining Engrs.	1905-1918	
Trans. Am. Inst. of Mining Engrs.	1871-1926	
Am. Inst. of Mining & Met. Engrs.	Vol. LX to Vol. LXXIII	
Am. Soc. Heating & Vent. Engrs.	1895-1925	
Municipal Engineering Jour.		1916 to 1921
Am. Soc. of Municipal Improvements	1901-1932	
American Journal of Public Health	1905-1907, 1913	
	1916-1933	1934 to 1939
The Military Engineer	1910-1930	1931 to date

The procedure for discarding material would be to leave it on the shelves until more space is required. Upon removal from shelves it would be placed in temporary storage and other libraries contacted to see if they desire such material. If no library desires the material then the members would be canvassed. Finally if there are no takers and over a period of six months to a year no requests for any of the material has been made by library users thus indicating that such material should be retained, the material would be disposed of as waste paper.

c) That the present files of publications of the Engineering Societies listed in Table V be discarded. These are generally incomplete files and are in most cases old.

d) Only the following technical periodicals be bound and kept in permanent files.

Periodical	Present Available	Subscription	Binding Cost
Engineering News Record	1878 to date	$3.33	$12.20
Civil Engineering	1930 to date	4.00	4.50
Roads & Bridges*	1895 to date	2.50	4.50
Water & Sewage*		2.50	4.50

The last two are included because it appears that the B.S.C.E. library has the only extensive file of the Canadian Engineer in the city.

*Formerly Canadian Engineer.

e) That the technical periodicals listed in Table VI be kept unbound and in a five year current file only.
f) That the technical periodicals listed in Table VII be discarded. The files of these publications are incomplete and some of the publications have been discontinued.

4. The following policy regarding books to be adopted:
a) New books of general interest to the Society to be added to the Library from time to time as available.
b) That the various sections of the Main Society appoint committees

TABLE VI—PERIODICALS TO BE KEPT UNBOUND AND FOR FIVE YEARS ONLY

Periodicals	Subscription
Water and Sewage Works	$1.50
Sewage Works Engineering	2.00
Water Works Engineering	2.50
Iron Age	8.00
Public Works	2.50
Railway Age	5.00
Roads and Streets	2.50
Electrical World—Power	7.00
Industrial Standards (Am. Standards Assoc.)	Exchange

TABLE VII—PERIODICALS TO BE DISCARDED

Periodical	Bound	Unbound
*Power	1916 to 1932	1933 to date
*Iron Age	1920 to 1934	1935 to date
*Public Works	1903 to 1931	1932 to 1938
	1939 to date	
*Railway Age	1876 to 1934	1935 to date
The Engineer (British)	1864 to 1932	1933 to date
American Architect & Building News	1900 to 1932	
Architectural Forum	1922 to 1945	
Electric Railway Journal	1902 to 1931	1932 to 1943
American City	1914 to 1932	
Concrete	1914 to 1939	
*Roads & Streets		1931 to date
Engineering & Mining Jour.	1875-78, 1893 to 1902, 1921 to 1932	
Engineering & Contracting	1908 to 1930	
*Water & Sewage Works	1909 to 1931	1932 to 1938
	1939 to date	
Engineering	1872 to 1932	

*Current publications to be kept unbound for 5 years only.

to advise the library committee of worthwhile books relating to their respective fields.
c) That obsolete books be removed from the shelves and be discarded as they outlive their usefulness.
d) That the books of historical or classic interest in the files be grouped by subjects and constitute a historical library. The various subjects would include the following: Hydraulics; Water Supply; Sewage Dis-

posal; Railroads; Bridges; Buildings; Highways; Canals and Rivers; Dams; Biographies; Miscellaneous.

The representative committee of the various sections would assist the library committee in setting up this historical library. Additional subjects should be added to the list as suitable material becomes available.

5. The following policy regarding Governmental reports, maps and similar material be adopted:
   a) Tentatively only the following material to be considered worth keeping in the files, but a sub-committee should be organized to determine what additional material should be placed in the files and the findings of this committee to be the subject of a future report.
      U.S.G.S. Water Supply Papers
      U.S.G.S. Topographical Maps (Whole U.S.)
      Reports of Chief of Weather Bureau
      U.S. Census Reports
      Metropolitan District Commission Reports
6. The following policy to be used regarding the library committee:
   a) That the library committee be comprised of the following:
      Chairman appointed by the Board of Government;
      Librarian appointed by the Board of Government;
      Four members, one from each of the sections and recommended by the Section.
   b) That a librarian who is a member of the Society be appointed to serve without pay. This librarian would act as the executive of the library committee.
   c) That the librarian's duties be designated as follows:
      Direct the activities of the paid library personnel recommended in paragraph (1);
      Shall be responsible for the arrangement of all material on the shelves;
      Shall be responsible for the purchase of new books, the renewal of subscriptions, and for the binding of periodicals;
      Shall be responsible for the cataloging of all books;
      Shall keep an approximate record of the use of the Library.
7. That the map file and filing cases recommended for purchase by the committee in their preliminary report to the Board of Government, in September, be purchased.
8. That the Board of Government make available to the library committee the following sums of money to be used as necessary to renovate the library. This appropriation would be for one year only and would be in addition to the usual funds made available for the purchase of new books.

Hire for part time experienced librarian	$750
For cleaning books and shelves	250
Binding periodicals and repairs to wornout bindings	500
Additional Map File	150
Steel Filing Case (letter size).	75
	$1,725

The above policy does not cover all the miscellaneous material contained in the library but it does cover the major portion of the library contents. There may be some discrepancies in the dates of publication shown, for this the committee apologizes but it represents the best that could be done until the library is completely overhauled and some of the scattered material brought together.

APPENDIX "B"

January 14, 1947

(Addressed to Member Societies of E.S.N.E.)

The Library Committee of the Boston Society of Civil Engineers is studying the rehabilitation of the Society's Library. The first step in this rehabilitation is to formulate a workable policy to serve as a basis upon which to operate. This letter is an informal request sponsored by the committee to determine if there is any interest on the part of member societies of the E.S.N.E. to participate in any way in this library.

Briefly the history of the BSCE library is as follows:

The BSCE was founded nearly 100 years ago by the eminent engineers of the day and who covered probably all fields of engineering. One of the primary functions of the Society as stated in its Constitution is to maintain a library. Previous to the depression the Society had a creditable and well patronized library. This library was principally a Civil Engineering Library.

With the depression the Society's income was reduced and in an effort to reduce expenditures, funds for the maintenance of the library were drastically cut. This curtailment of funds has largely continued until the present and the library is now badly disorganized.

The enclosed table indicates certain material now in the library and which is not strictly Civil Engineering material.

As you are probably aware the ESNE rents office space in the BSCE quarters for $500 per annum and pays $100 additional for use of the library and rooms by its members. In return the BSCE pays the ESNE approximately 80 cents per year for each of its 700 odd members and last year paid the ESNE $551.23. Certain publications of member societies have been donated to the library to become the property of the BSCE as is indicated by the enclosure.

The committee would be interested in obtaining the following information from your Society.

1. Would your society care to participate in a library that would cover your respective field plus the Civil Engineering field? This procedure would require some financial assistance.
2. In lieu of (1) would your society care to donate to the BSCE library bound copies of your periodicals thus making a reference of such material available to your members in downtown Boston?
3. In lieu of either (1) or (2) should the committee assume that you are not interested in such a library and would be indifferent to the disposition the BSCE might make of any of the material listed in the enclosure.

The Library Committee would welcome the opportunity to discuss the matter in more detail with representatives of your society if you so desire. The committee will appreciate a prompt reply since it hopes to formulate its program previous to the Annual Meeting of the BSCE on March 19, 1947.

Very truly yours,

A. B. Edwards

Chairman BSCE Library Committee

NON-CIVIL ENGINEERING PERIODICALS NOW IN THE BSCE LIBRARY

Periodical	How Obtained	Now Available Bound	Now Available Unbound	Possible Future Disposition
A.S.M.E. Trans.	Gift of ESNE	1880-Date		A
A.I.E.E. Trans	Gift of ESNE	1896-Date		A
A.I. Mining—Met. Trans.		1871-1925		D
Jr. Am. Welding Soc.	Gift of ESNE	—	Current	C
Proc. Inst. Radio Eng.	Gift of ESNE	—	Current	C
Mech. Engr.	Gift of ESNE	—	1921-Date	B
Illuminating Engr.	Gift of ESNE		Current	B
Contact	Gift of ESNE	—	Current	C
Gen. Elec. Review	Gift of ESNE	—	Current	C
Edison Elec. Inst. Bull.	Gift of ESNE	—	Current	C
Boston Business	Gift of ESNE	—	Current	C
Bell System Tech. Jr.	Exch. for BSCE Jr.	—	Current	C
Electrical World	Subscription	1908-1940	1941-Date	B
Power	Subscription	1916-1932	1941-Date	B
Iron Age	Subscription	1920-1934	1941-Date	B
The Engineer (British)	Subscription	1864-1932	1933-Date	B
Jr. Franklin Inst.	Exch. for BSCE Jr.	1826-1932	1933-Date	C
Bull. Am. Inst. Mining Engrs.	—	1905-1918	—	D
Trans. Am. Inst. Mining Engrs.	—	1871-1926	—	D
Am. Inst. Mining & Met. Engrs.	—	Vol. LX - Vol. LXXIII		D
Am. Soc. Heating & Vent. Engrs.	—	1895-1925	—	D
Engrg. & Mining Jour.		1875-78, 1893-1902 1921-1932		D

A—Complete file kept up to date.
B—Unbound keep for 5 years only.
C—Unbound keep for 1 year only.
D—Discard.

REPORT OF THE COMMITTEE ON RELATIONS OF SECTIONS TO THE MAIN SOCIETY

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

This committee held no formal meeting during the year, though the Section chairmen have conferred individually, and four joint meetings with the main Society have been held. In January a post-card questionnaire resulted in a vote that no formal meeting was necessary.

Respectfully submitted,

DEAN PEABODY, JR., *Chairman*

REPORT OF THE COMMITTEE ON SUBSOILS OF BOSTON

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

The Committee on Subsoils of Boston has been inactive during the past year, since it has not been feasible during this period to collect data on borings, water table elevations, etc., which is the main program proposed by this committee in former years.

Therefore no report of this committee will be submitted at this time.

Respectfully submitted,

DONALD W. TAYLOR, *Chairman*

REPORT OF THE JOHN R. FREEMAN FUND COMMITTEE

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

Last May the committee offered a scholarship for a year's study of research work in connection with hydraulics or an allied science. The scholarship provided $2,400 for a single man or $3,000 for a married man. Preference was offered to residents of New England and eastern New York north of New York City. The award was to be made to a candidate who presented the best project and was best qualified to carry it through. The notice was sent out May 20th to all the engineering schools in the area, and also published in the engineering bulletins and magazines.

No applications were received. It apparently was too soon for men back from the war to have a chance to get themselves sufficiently established educationally or professionally to be able to formulate plans for such study. The committee believes however there should be many applications for such scholarship offered this spring.

No plan for this year has yet been made, but the committee will probably again offer a scholarship of some form.

For the John R. Freeman Fund Committee,

HOWARD M. TURNER, *Chairman*

REPORT OF THE COMMITTEE ON QUARTERS

Boston, Mass., March 19, 1947

To the Boston Society of Civil Engineers:

Early last Spring after discussion, the committee decided that any consideration of permanent quarters to be used with other engineering societies should be undertaken jointly with the ESNE. Accordingly an approach was made to the council of that Society which appointed its own committee, and joint meetings were held to discuss such a project. During the summer a questionnaire was sent out to the member societies and data obtained as to the number, size and character of the meetings of their societies.

It was decided by this joint committee that, in order to find out the interest of the various societies in the project of a central engineering headquarters, it would be necessary to present some fairly definite plan. It is difficult to get anything really definite at such an early stage, but inquiries were made from a real estate concern as to property available and its cost and the advice of a lawyer was obtained on the question of taxation. The results may be summarized as follows: A building could probably be purchased by the engineering societies and remodelled to provide facilities for meetings of not over 150 people and sufficient space for a library, offices, janitor's living quarters and kitchen suitable for the use of a caterer, for not less than $50,000 but probably not over $100,000. If such a building were owned by the engineering societies jointly, so that it was non-taxable, the annual additional costs of fixed charges and operating expenses would be between $1.00 and $2.00 per year per person of the 5,700 members of the ESNE.

These figures were presented at a recent meeting of the Council of the ESNE, and referred to the President or Chairman of each of the Affiliated

Societies, with the suggestion that their counselors be instructed as to whether or not they would be interested in such a project. It is expected that a vote authorizing the executive committee to proceed with arrangements for new quarters will be taken in April.

Until this question is settled it has seemed to your committee inadvisable up to date to take any active steps in looking for new quarters for our Society alone. Such a search might well be undertaken now pending the receipt of information as to the ESNE's interest to the larger plan.

Respectfully submitted,

HOWARD M. TURNER, *Chairman*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION

Boston, Mass., March 5, 1947.

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year four meetings have been held as follows:

March 6, 1946.—Annual Meeting and election of officers. Mr. George W. Coffin presented a paper entitled "The Proposed Southampton Street Refuse Incinerator, Boston, Massachusetts". Attendance, 61.

June 5, 1946.—Mr. Edward L. Winslow spoke on "Water Supply and Sewage Disposal in Bermuda". Attendance, 52.

October 2, 1946.—Messrs. George F. Brosseau, C. Frederick Joy, Jr., and Norman Winch spoke on "Assessment and Connection Practices in Three Greater Boston Sewerage Systems". Attendance, 29.

December 18, 1946.—Joint Meeting of the Boston Society of Civil Engineers and the Sanitary Section. Mr. Richard H. Gould spoke on "Sewage Disposal in the City of New York". Attendance, 110.

The average attendance was 63.

Five meetings of the Executive Committee have been held during the year.

Respectfully submitted,

GEORGE C. HOUSER, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE DESIGNERS SECTION

Boston, Mass., March 10, 1947.

To the Designers' Section, Boston Society of Civil Engineers:

During the past year the following meetings were held:

March 13, 1946.—Annual Meeting and election of officers. Mr. Daniel O. Casgill spoke on "Construction and Maintenance of Bridges". Attendance, 40.

April 10, 1946.—Mr. J. Stuart Crandall presented a paper entitled, "Comments on Breakwaters". Attendance, 44.

May 8, 1946.—Mr. Abraham Woolf delivered a paper on "Factory Roofs". Attendance, 36.

October 9, 1946.—Mr. Francis R. MacLeay presented a paper on "The Solution of the Housing Problem". Attendance, 70.

November 20, 1946.—Joint Meeting of the Designers' Section and the Main Society. Mr. Chester N. Godfrey, Professor Arthur Casagrande, and Mr. H. M. Parsons spoke on "The Foundations for the New John Hancock Building in Boston". Attendance, 210.

December 11, 1946.—Joint Meeting of the Designers' Section with the Transportation Section. Mr. Henry L. Kennedy presented a paper on "Application of Entrained Air in the Production of Better, More Durable Concrete". Attendance, 75.

January 8, 1947.—Mr. R. H. Davis spoke on "Recent Progress in Structural Welding". Attendance, 52.

February 12, 1947.—Mr. Arthur P. Grimm spoke on (a) "Wrought Iron", and (b) "Radiant Heating and Snow Melting". Attendance, 67.

Total attendance was 594.

The average was 74.

Respectfully submitted,

ERNEST L. SPENCER, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE TRANSPORTATION SECTION

Boston, Mass., March 4, 1947.

To the Transportation Section, Boston Society of Civil Engineers:

On April 8, 1946, the Highway Section, which had been in existence since May 1, 1924, was renamed the Transportation Section.

On September 17, 1946, Mr. John F. Shea resigned as clerk of the section and Mr. Thomas C. Coleman was appointed Acting Clerk on October 23, 1946.

During the year three meetings were held as follows:

April 17, 1946.—Mr. A. J. Bone, Associate Professor of Highway Engineering, Massachusetts Institute of Technology, presented a paper on the subject of "Airport Site Planning". Attendance, 40.

December 11, 1946.—This meeting, originally scheduled as the regular November meeting, was postponed to this date in order to hold a joint meeting with the Designers' Section. Mr. Henry L. Kennedy, Manager of the Cement Division of the Dewey and Almy Chemical Company, presented an illustrated talk on the "Application of Entrained Air in the Production of Better, More Durable Concrete". Attendance, 75.

February 26, 1947.—A joint meeting with the Main Society was held on this date. Col. Enoch R. Needles, partner in the firm of Howard, Needles, Tammen and Bergendoff, Consulting Engineers, New York, spoke on the "Maine Turnpike Project". The talk was illustrated with slides. Attendance, 170.

The total attendance at the meetings was 285.

Average attendance, 95.

Respectfully submitted,

THOMAS C. COLEMAN, *Acting Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE HYDRAULICS SECTION

Boston, Mass., February 11, 1947.

To the Hydraulics Section, Boston Society of Civil Engineers:

The following meetings were held during the past year:

May 22, 1946.—Mr. Byron O. McCoy presented a paper entitled "Hydraulic Design of Intake Structures". Attendance, 36.

November 6, 1946.—Mr. Richard H. Ellis presented a paper entitled "Water Supplies for Industrial Fire Protection". Attendance, 38.

January 22, 1947.—Joint Meeting with Main Society. Mr. Nathan B. Jacobs presented a paper entitled "The Water System of the City of Philadelphia and Proposed Supply from Upland Sources". Attendance, 82.

February 5, 1947.—Prof. Arthur T. Ippen presented a paper entitled "Standing Waves in Open Channels". Attendance, 28.

The total attendance was 184.

The average attendance was 46.

Respectfully submitted,

J. G. W. THOMAS, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE NORTHEASTERN UNIVERSITY SECTION

March 7, 1947.

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

The following meetings were held during the past year:

January 17, 1946.—Dean W. T. Alexander, Dean of the College of Engineering spoke to a joint meeting of ASCE, ASME, ASEE, AICE of his duties and of places he visited during his five years in naval service. While in the Navy, Dean Alexander served as engineering officer on an attack transport. Attendance, 175.

March 26, 1946.—Mr. Louis Berger, president of C. L. Berger and Sons, Instrument Makers, gave an address entitled, "New and Accelerated Methods Applied to Engineering". Mr. Berger stressed in his talk speed and accuracy and described the development of a military level by his company for the Army Engineers. At the conclusion of his talk, he presented one of these military levels to the University. Attendance, 40.

May 9, 1946.—Elections were held for N.U.C.E.S. officers for the next year. Results were as follows:

President—Louis L. Lunetta
Vice-President—Robert Pierce
Treasurer—Bernard F. Stone
Secretary—Richard W. Newcomb

Attendance, 74.

May 16, 1946.—Mr. Adrian Sawyer, president of the Sawyer Construction Company, spoke on the opportunities for young engineers and the qualifications needed by them. Among the points stressed by the speaker were: ability to speak, knowledge of values, self-appraisal, ability to concentrate, observation, common sense, conviction and neatness. Attendance, 25.

September 25, 1946.—A field trip was conducted to the site of the new twenty-six story John Hancock building where the driving of piles was inspected. These piles were 14 inch, 117 pound H beams which were used because of the presence of water over the bed rock. This water prohibited the use of open caissons as the water would blow up through them. Attendance, 25.

October 3, 1946.—A business meeting of the N.U.C.E.S. was conducted and plans were made for the Annual Student Night, A.S.C.E. Northeastern Section. Attendance, 30.

October 10, 1946.—Mr. Francis MacLeay, Chief Engineer of the Corbetta Construction Company of New York, spoke on "What Is a Civil Engineer". Mr. MacLeay defended his profession against the accusation of having a "Jack of all trades, master of none", explaining their positions as organizers, advisers and designers. Attendance, 40.

October 28, 1946.—Col. C. T. Newton, Corps of Engineers, Director of U. S. Waterways Experiment Station at Vicksburg, Mississippi, spoke on "Engineering Services of the U. S. Waterways Experiment Station" to a joint meeting of the Boston Society of Civil Engineers, Northeastern Section of the American Society of Civil Engineers and student chapters. Attendance, 85.

December 4, 1946.—Mr. Richard W. Newcomb, a civil engineering student, presented a student paper entitled, "Automatic Sprinkler Systems". The paper was based on co-operative work experience of the speaker with the Associated Factory Mutual Fire Insurance Companies of Boston, Massachusetts. Attendance, 65.

December 10, 1946.—An organization meeting was held during which the election of officers for the coming year was held. Results were as follows:

President—C. E. Sullivan
Vice-President—J. J. Colarusso
Secretary—A. L. Quaglieri
Treasurer—F. D. A. King

The average attendance for these meetings is 43. It will be noted that this average does not include the attendance of the joint meeting of ASCE, ASME, ASEE, and the AICE. All the students present at the Annual Student Night Joint Meeting were student members of the Boston Society of Civil Engineers.

Respectfully submitted,

LOUIS L. LUNETTA, *Executive Committee Chairman*

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

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1947-1948

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Charles O. Baird
Allen J. Burdoin
Frank L. Lincoln
(Term expires March, 1948)

Dean Peabody, Jr.
William L. Hyland
Walter E. Merrill
(Term expires March, 1949)

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Stanley M. Dore
William L. Hyland
Edwin B. Cobb
Miles N. Clair
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George W. Hankinson
George F. Brousseau
Henry I. Wyner

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Charles E. Knox, *Chairman*

John B. Babcock
Harold A. Thomas, Jr.
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Library

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John H. Harding, *Chairman*

Charles T. Main, 2nd
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Edward S. Averell

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George F. Brousseau
Henry I. Wyner
George W. Hankinson
Clifford E. Sullivan

Welfare

Ralph W. Horne, *Chairman*

John R. Freeman Fund

Howard M. Turner, *Chairman*

Charles M. Allen
William F. Uhl

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Dean Peabody, Jr., *Chairman*

Harold A. Thomas, Jr.
Walter E. Merrill

Sanitary Section Award

Walter E. Merrill, *Chairman*

George C. Houser
Truman H. Safford

Hydraulics Section Award

Harold A. Thomas, Jr., *Chairman*

Richard H. Ellis
George N. Bailey

Designers Section Award

Dean Peabody, Jr., *Chairman*

Frank L. Lincoln
Oliver G. Julian

Transportation Section Award

Dean Peabody, Jr., *Chairman*

Ernest L. Spencer
Francis T. McAvoy

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