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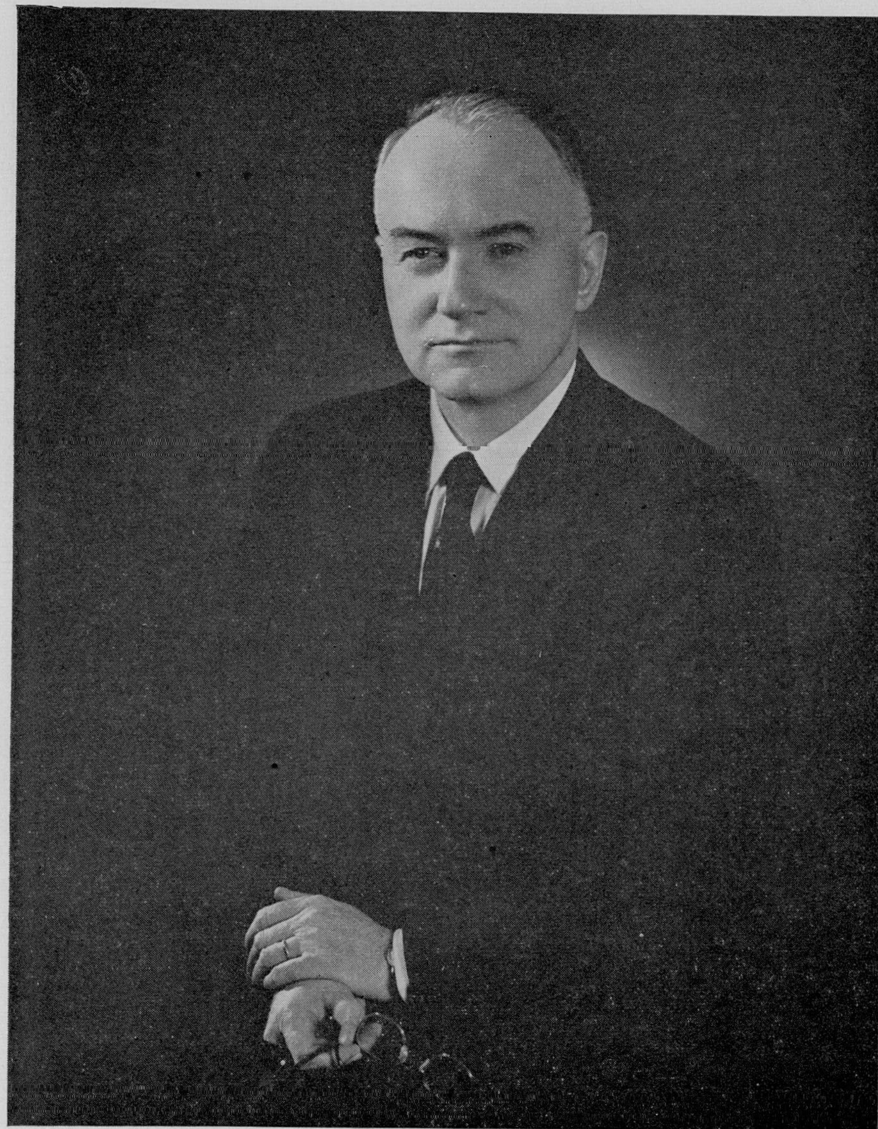

WILLIAM L. HYLAND

President

Boston Society of Civil Engineers

1958-59

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A EUROPEAN VIEW OF THE AMERICAN EDUCATIONAL CRISIS

Presidential Address by ARTHUR CASAGRANDE*

Boston Society of Civil Engineers, March 19, 1958.

"Apathy can only be overcome by enthusiasm, and enthusiasm can only be aroused by two things: First, an ideal which takes the imagination by storm, and second, a definite intelligible plan for carrying that ideal into practice."

—Arnold Toynbee

INTRODUCTION

DURING the past thirty years I have been interested in a comparison of American and European schools and in the reasons for the great differences. This presidential address seemed to me an appropriate occasion for summarizing my impressions. When the first Russian satellite crossed our skies, it released such an avalanche of publications and pronouncements on the faults of American schools that I concluded that anything I had planned to say in this address would soon be said a hundred times. But the more I read, the more I realized that my message may be even more pertinent now than before the event of the Sputniks, for this reason: There is general agreement among the critics that the principal fault with our educational system lies with the low quality of the teachers and that this in turn is the result of their miserable salaries and their low social status. Also, there is a widespread belief that most of the grave deficiences of our public schools could be cured with money alone, chiefly by paying the teachers appropriate salaries and by providing ample financial support for the students. If this were really true, our difficulties would indeed be simple to solve. But I believe that the roots of

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our troubles lie deeper, and that our current efforts will not succeed without an understanding of the reasons why teachers' salaries are so low in this wealthiest country of the world, why our high school curricula are in such a hopeless condition, why our students find so little motivation, and why, by and large, such difficulties have not arisen in the major European countries.

Having had personal experience with European schools, I am perhaps in a better position to make comparisons than my colleagues who have only a reading or hearsay knowledge of European schools. So that you will understand my conclusions and in order to permit you to use my analysis for the purpose of forming or revising your own ideas on this problem, I must review briefly my own impressions of what the European schools have done for me.

Through Austrian Schools

I attended public schools and high schools in three cities in the old Austrian Empire, starting in 1908 at the age of six and graduating from the type of high school that prepares one for an engineering university.

You have all read so much about the Russian high schools that it simplifies my task of describing the scope of our courses in mathematics and sciences by saying that Russia seems to have done an excellent job of imitating the school system of their western neighbors. To assist you with another comparison, I can say that the amount of physics, chemistry, spherical trigonometry and principles of calculus were at least equivalent to what the American students cover in their first year of an engineering school. We had actually more descriptive geometry in high school and more intensive training in drawing than graduates from American engineering schools.

I began the study of Italian and French in a high school in Trieste, and continued in Vienna with French and English. While I regret to say that our proficiency in speaking these foreign languages was far less than one would assume from the great amount of time devoted to their study, we did master grammar, a good reading knowledge and the ability to translate both ways. The language courses included valuable information on life and the people of France and England, their literature and governments, explained by teachers who had studied in those countries, and what to me in retrospect is more remarkable, taught lovingly, full of human interest and without the slightest animosity that might have been expected at a time when Austria was at war with those countries, at a time when teachers and pupils alike suffered seriously from food shortage, and we often shivered in our winter coats in unheated class rooms.

From the first day I entered school at the age of six, homework formed an essential part of our training. In high school, about 30 classroom hours and at least 25 hours a week of homework left precious little free time; a fact I often resented, I must admit. Class hours were from eight to one o'clock daily, including Saturday. A few afternoon classes were chiefly for electives, such as shorthand, which practically every student took because it was considered important for taking notes. In fact, I found it indispensable, particularly in my university courses.

The high school program was well integrated, well taught by teachers who really knew their subjects, and most of the text books were excellent. "True or false" methods of testing were unknown.

Probably not one of my high school teachers would have qualified to teach at American high schools because they lacked the intensive training in educational courses that is the primary requirement for obtaining a teacher's license in the United States. But most of them had a doctor's degree, one had two doctor's degrees. In my considered opinion most of them would also have made excellent university teachers. Because the younger teachers were in the war, many retired teachers were called back. My physics and mathematics teachers were well over seventy and were both brilliant and most stimulating. It is almost forty years since I graduated from high school, and some subjects have experienced much change. Nevertheless, there is no question in my mind that the high school education I received at that time would even today permit me to enter without any difficulty directly into the sophomore year of any American university.

Bewilderment About American Education

Since 1926 I have become well acquainted with all parts of our country and fairly well acquainted with many other countries. Almost everywhere I go, I meet people who are well-informed about local conditions in education, and in this manner I have accumulated a reasonably good knowledge of the good and bad things about education in many places.

For some years after my immigration, I could not resist pointing out to my colleagues how much time the American student of engineering must devote to subjects that in my opinion are high school stuff. What was most astounding to me was that he had not mastered the use of his own language and still had to take courses in English. But I soon gave this up for two reasons: First, I found out that this was not the way to make friends, because I only reaped resentment; and what was worse complete disbelief in my statements, even on the part of teachers who I thought had some knowledge of European education. The second and more important reason was that I began to have doubts whether all this intense study that Europe demands of its young people was really necessary. Here I was, in this fabulous country, which at least in the eyes of a young and eager civil engineer was well ahead of Europe, and all this achievement brought about with much less effort in the schools; with much more free time for the young people to pursue happiness. It was bewildering. Only many years later did I begin to realize that these deficiencies were supplemented by the solid achievements of many European-trained men and how much in fact this country depended on the products of the European school systems. It was not until I began to read some of Dr. Conant's first warnings, about 1935, on the serious consequences that insufficient training in sciences and languages in our high schools would have, that I began to trust my own impressions. But an understanding of the reasons for the differences between European and American education came to me only much later.

A Comprehensive Solution Requires Centralized Guidance of Education

The high standards and achievements of European schools are the result of generations of enlightened governmental efforts. The system has evolved slowly under the guidance of the best qualified men the governments could find for this responsible task. Men with an outstanding record as university or high school teachers or school principals are promoted into responsible positions in a Department or Ministry of education where they carry on with only a minimum or no political interference.

There is little difference between the school systems of such neighboring countries as Germany, the Scandinavian countries, Switzerland and Austria, not as a result of deliberate cooperation, but merely by knowing about the successes and failures of educational efforts across the borders. These countries have achieved much greater unity in education than have different high schools in the United States, even within the same city.

Let me ask this question: If the people of those European countries that are doing so well in education, were forced to run and regulate their schools in the manner we are accustomed to in our country, could they possibly have reached the same achievements? My guess is that if their schools were organized on the level of individual communities, controlled by local school boards which in turn are controlled by low-level politics, and if each community had to vote on the salary increases of their teachers, etc., that they would be in the same mess that we are in; simply because the average European citizen is not superior to the average American citizen.

Recently a top Government official in Washington made the following statement: ". . . in the last analysis it is up to the parents to decide what education their children will get." I dare say that it is just because of what the parents are doing, or rather not doing, that we have been slipping steadily. With far too few exceptions, the great majority of the people are simply not able to grasp this problem, and they will not vote voluntarily to pay more taxes in order to double the salaries of the teachers in their community.

So many arguments are advanced against Federal Government guidance of education, that I should like to add more reasons in favor of such guidance.

Certainly everything that concerns the security of our nation in the broadest sense of the word, should be under bipartisan control; and that includes first, our defense system; second, our foreign policy; and third, education. Fortunately, it is now being widely recognized that education has moved into the front line of our defense system and that we could lose a war, or that we will surely lose heavily in economic competition and suffer in prestige if we continue to neglect education as we have been doing in the past. To allow individual school boards to control education in this age seems to me just as stupid as if we let our armed forces and all our defensive efforts be splintered into innumerable local units, allowing each unit to be autonomous in its decisions. If the survival of our country demands that our young men don uniforms in peace time or go to war under Federal control, it is equally important for our security that our youth should receive the best possible education, and that is hardly possible under our present system.

Finally, let us not forget that there are not enough sufficiently qualified men to run our educational system on a community level. There are barely enough good men in the entire country to staff a central organization in order to accomplish what must be accomplished. Only by pooling the resources of the entire country can we achieve the high quality of leadership that is absolutely necessary for this task. I visualize that staffing a Federal Department of Education would mean that a handful of outstanding high schools (e.g., Newton High in Greater Boston and the Washington High in San Francisco) and several of the private schools in the east, would lose their eminent principals; and that some well-known university professors would have to give up teaching; and that this group would have to be headed by a man such as Dr. James Bryant Conant, who was probably the first eminent scientist and educator who clearly recognized more than twenty years ago the dangers in our school system and has courageously tried to do something about it.

As a transitional step, it may be necessary to establish through private initiative standards for the scholastic competence of teachers and for high school curricula. Such an effort, combined with a tightening of entrance requirements to universities, would certainly achieve a great deal. But it might be too little and the results may come too late.

Other Difficulties in American Education

Even if we replaced the present localized administration of American education by competent Federal guidance, we will still find it much more difficult to achieve European standards because the American high school student is suffering from two serious handicaps as compared to his European cousin; lack of incentives and lack of sufficient time for study.

When I was a student in Europe there was no want of incentives. I recall that some of my hardest working colleagues came from poor families with a low level of education. The parents were anxious to help their children to a better life than they had known, even if it meant great sacrifice; and the children saw the example of parents who were poor in spite of long hours of hard work. Such an environment is a powerful incentive. I am sure that much of the hard work of Russian students is due to similar circumstances, only probably more so. In particular, he sees that scientists and engineers have many desirable privileges and more than other professions. In contrast, the American high school student grows up in a civilization of plenty. Even without a university education he sees his parents earning a good living in 35 hours a week. The teenager grows up in a surrounding which does not teach him the importance of hard work. In fact, he sees many instances of uneducated men earning much more than university graduates; and finds his own teachers nearly at the bottom of the list when it comes to income. How can we then convince our students that they must work 50 hours a week or more and give up most of the fun that others of their age demand and get? To develop powerful incentives in our environment is a difficult problem that we must somehow solve.

Lack of time for study is for the American teenager a much more serious problem than for his European counterpart; or perhaps I should qualify this by saying, as it was when I attended high school in Vienna. There, his occasional evenings out were for the theatre, the opera, or a movie. Coeducation did not exist for grammar and high schools, so that the teenage boy could more easily keep his mind on his work. Furthermore, dating and going steady for teenagers, and other incentives for premature mating, had not yet been invented, and so he did not have to worry about borrowing a car from dad for the evening, and devote his time to all sorts of jobs to enable him to buy his own car. Last but not least, he did not see his parents enjoying TV shows while he struggled to keep his mind on his homework.

Apparently our civilization has advanced far beyond the point that might be considered an optimum environment for providing powerful incentives and the time for long hours of serious study. Even parents need new incentives so that they will do their share in motivating their children to exert themselves in their studies. There are indeed few parents who realize that the time which their children have at home is much more valuable than the time the grown-ups have at home; that the parents can afford to spend many hours every day before their TV set without doing themselves any harm, but that their children cannot afford it if they hope to enter a university, particularly for an engineering or scientific career.

Finally, it should be mentioned that the lack of homework during most of his preceding years in school finds our senior high school student ill prepared to cope effectively with a large amount of homework during the last two years of high school, even though he may be perfectly willing to buckle down.

To counteract these serious handicaps we need the wisest of leadership which will assure the development of schools that are not only as good but better than the European schools. If we expect this leadership from the present school boards and PTA meetings, we are expecting to lift ourselves by our own bootstraps. Wise and effective leadership can be exerted only from the top down, not from the bottom up.

Specific incentives of a minor nature that might prove quite helpful and certainly worth trying, are the following:

(1) Reduce the time for military service to say eight months for high school students who have completed satisfactorily a specified curriculum, which should include ample mathematics, physics, chemistry and languages.

(2) All tuition fees should be allowed as deductions for Federal and State income tax purposes. This would be particularly helpful to all privately endowed schools on which we are now greatly dependent for scholastic leadership.

The Immediate Need for Effective Interim Measures

Even under the most favorable conditions it would require at least ten years to bring about the necessary reorganization of the American school system. We must bridge the gap between the present situation and the time when this job will be finished, by interim measures which will assure the most efficient utilization of what we now have. Because of the low efficiency with which our educational resources are used, and because of unused potential resources, we stand a good chance of making a remarkable progress in a short time, if only the problem is dealt with squarely. What should be done without delay can be summarized as follows:

1. With Federal aid raise the teachers' salaries at least 50%; or exempt their salaries from all income taxes.
2. Upgrade the teachers we have; relax licensing requirements to encourage men and women who are qualified in mathematics and the sciences to go at least part-time into teaching.

3. Discontinue the use of all but the best textbooks and arrange for competent men or panels to write new books where necessary.
4. Let a cooperative effort of universities establish plans of study which high schools must adopt for those students who want to go to college.

Let me be more specific on several of these points.

Next to the high school students in our country, it is the teachers for whom I feel deep sympathy. By no fault of their own they have not been trained properly for their job. In the course of years of often bitter experience they realize their shortcomings and would like to do something about it. If they go back to school for a master's degree, to assure themselves, among other things, a bit more than starvation wages, it merely means more and more education courses. If they want to concentrate in their field of specialization, they are out of order and up against all sorts of obstacles. Then back to school where they are mentally crushed between the selfishness of low-level political control that sometimes even dictates the use of mediocre textbooks, and the incompetence of parents, many of whom consider themselves educational experts, and to whom they must listen in time-consuming PTA meetings. To me it is always a great surprise and encouragement to still find dedicated teachers carrying on under such discouraging conditions. But instead of honoring their devotion by a monument, they are frequently made the scape goats for everything that happens, so that they hardly dare to defend themselves against undisciplined or even criminal children, because firm discipline is outlawed by modern educational theories as well as by parents.

The shortage of competent teachers could be effectively controlled by making extensive use of retired teachers. Among them are married women whose husband's income is such that much of what they would earn would again be lost in taxes. By making teachers' salaries free of income tax, or if not the entire salary at least the first $3,000, it would be a very persuasive argument for many retired teachers to return to their jobs, at least for part-time assignments. Not only are many of the retired teachers much more valuable because of their long experience, but many have a better command of their subjects than young teachers who are just now entering the profession.

As to textbooks, I cannot talk on this subject without the danger of reaching my boiling point. Not only in high schools but in colleges, many of our students use inferior textbooks, when good books are available. And constantly a flood of new but low-grade books are being printed, even though some older available books on the same subject may be outstanding.

I happen to know from a reliable source that the Russians are quite diligent in translating the best textbooks from other countries. They are mostly European, but with a sprinkling of American books. I know some of the American books they have translated and they are the best in that field. They choose for their own students only the best of our books, while in our country most of our students and many of the teachers do not even know which books are the best, and they may be blissfully ignorant of the low quality of the books that they are using.

Unfortunately, it is true that with this enormous number of textbooks that we are turning out every year, it is most difficult for a teacher to find the best ones, assuming that he is permitted the choice, which is not often the case. In order to utilize our educational resources to the fullest, it is imperative and only common sense that we should exert every effort, by means of panels of qualified men, to classify all books that are used in our schools. By publishing such listings, and by pointing out the merits and demerits of each book, school authorities would soon be forced to introduce the best available books, and the writing of better books would be encouraged.

The use of only the best textbooks combined with much more homework and book study could help the students to overcome the present deficiencies of class room instruction. It would also help to upgrade the poorly trained but hard-working teachers if they were guided to use only the best of books.

Closing Remarks

My own outlook for the future of education in this country is both pessimistic and optimistic. My pessimism is in part due to my observation that the great majority of those who in recent months have criticized our educational system so severely, have not developed their views in the shock wave of the Sputniks; they merely found the courage to speak their mind. Also, I wonder whether the great majority of those who read these statements do not belong in that same small group who have realized for years the dangerous shortcomings of American education? If so, then recent editorials that speak of the "awakening of the American public," etc., may well be overly optimistic. Instead we may soon see a dying out of the excitement and no substantial progress made.

But to me the most discouraging observation is that leading men in various professions whose judgment I trust, question seriously the feasibility of Federal control of education within a foreseeable future. They believe that a majority of our citizens would vote against the necessary amendment of our Constitution. However, it seems to me that a solution could be worked out which would not eliminate State control of education, such as adoption of Federal guidance on a voluntary basis, similar to Federal Aid for highways. To be eligible for such Federal Aid, the States must abide by certain minimum standards established by the Federal Government. In any case, the most immediate problem would be to educate all members of Congress to a realization that this is a matter of gravest urgency, that indeed it may be a matter of life and death.

Only one week ago I would have closed my talk on this pessimistic note. But in last week's *Time* magazine I read the good news about the eminent success of the high school text on Physics prepared by MIT's Physical Science Study Committee. The successful launching of that textbook and other vital contributions on which this Committee is working, may turn out to be a far more appropriate answer to Russia's launching of her Sputniks than getting our own satellites into orbit. I can only wish from the depth of my heart that the success of this first book may act like a beacon, and light up the darkness that hangs over our schools.

HURRICANE PROTECTION IN NEW ENGLAND

JOHN B. MCALEER,* *Member*, AND PETER J. A. SCOTT**

(Presented at a meeting of the Boston Society of Civil Engineers, held on May 15, 1957.)

GENERAL

THE three great hurricanes in 1954 caused salt-water flood damage of about $300,000,000 and loss of 60 lives in the Northeast. The September 1938 hurricane was even more severe and 500 lives were lost in tidal-flood areas. In view of the severe damages from hurricanes Congress authorized on 15 June 1955 an examination and survey of the eastern and southern seaboard of the Atlantic and Gulf coasts to be made under the direction of the Chief of Engineers, in cooperation with the Department of Commerce, mainly the Weather Bureau, and other Federal agencies concerned with hurricanes.

Congress directed that the survey should include the securing of data on the behavior and frequency of hurricanes, determination of methods of forecasting and improved warning services, and possible means of preventing loss of life and damage to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams and other structures, warning services or other measures which might be required.

The New England Division, Corps of Engineers, under the direction of Brigadier General Robert J. Fleming, Jr., and now under Brigadier General Alden K. Sibley, has prepared survey reports on the Narragansett Bay area, Rhode Island and Massachusetts, and on the New Bedford-Fairhaven area, Massachusetts. Reports recommending construction of protective works are waiting action by Congress.

Since these were among the first surveys of their kind directed by Congress the policies on Federal responsibility and participation in construction were not fully established and engineering precedent and techniques for large scale works were limited. It was necessary to collect a large amount of data, make unusually extensive basic investigations, and complete much original research to solve the prob-

*Chief, Hurricane Unit 1, **Chief, Hurricane Unit 2, New England Division, Corps of Engineers.

lems involved in the planning, design and economic analyses of protective measures.

The completed hurricane surveys of Narragansett Bay and New Bedford have been a joint effort. The New England Division Office has relied heavily on other Corps of Engineer units such as the Beach Erosion Board, Washington, D. C. (aided by the Texas A & M Research Foundation) and the Waterways Experiment Station at Vicksburg, Mississippi. Federal agencies, such as the Weather Bureau, Department of Commerce; the Fish and Wildlife Service, Department of the Interior; the Public Health Service, Department of Health, Education and Welfare; and the Coast and Geodetic Survey, Treasury Department, also have contributed valuable information. In addition, many State agencies of Massachusetts and Rhode Island, particularly the Narragansett Marine Laboratory of the University of Rhode Island, as well as a number of private engineering firms, have assisted in the studies.

The hurricane surveys have drawn heavily on the related experiences of the Corps of Engineers in river flood control, such as the designing and constructing of reservoirs, dikes, and flood walls; in harbor improvement, including designing and constructing breakwaters and jetties; in channel dredging, and in beach protection and tidal hydraulic investigations. The surveys have also drawn on the extensive studies of storm tides and dike design at Lake Okeechobee in Florida. The experiences of Dutch engineers in designing and constructing dikes against tidal flooding over a long period of time also have provided a valuable source of data.

In so new a field, engineers seek answers to a number of questions:

1. *How often may we expect hurricane floods?*

A review was made of historical data on past occurrences of hurricanes. According to available records, approximately 63 hurricanes have affected the Rhode Island and southern Massachusetts coast in the past 300 years. Of these, 25 have caused major or minor tidal flooding. The floods of 1635 and 1638 appear to have been the highest, with flood stages several feet higher than in 1938 or 1954. The records indicate that at least 2 hurricane floods occurred in the 17th century, 3 in the 18th century, 10 in the 19th century, and 10 in the first 55 years of the 20th century.

The more frequent occurrence of hurricanes and tidal floods in recent years does not necessarily indicate a greater trend in hurricane activity, but rather a lack of records and information prior to 1900.

2. *What causes tidal flooding?*

It was necessary to learn something of the mechanics of the hurricane surge that causes inundation of coastal areas.

In the open ocean the rise in sea level accompanying a hurricane seldom exceeds 3 feet. It is a low, flat wave, more than 100 miles long, which moves forward under the barometric low of the center of the hurricane, and is likely to travel 30 to 50 miles per hour in this latitude. This offshore tidal surge is built up not only by the force of the winds blowing around and toward the storm center, but also by differences in atmospheric pressure accompanying the storm. The rise in water level is roughly one foot for each inch drop in the barometer.

As the hurricane surge moves into the shoal water on the continental shelf, it is slowed by bottom friction and builds up in height in much the same manner that an ordinary ocean wave slows down and builds up into a ground swell as the water shoals. In this way, a 3-foot offshore surge may increase to 6 or 8 feet in Block Island Sound, and reach a height of 8 or 10 feet above high-tide level on the exposed coast.

In bays and estuaries the rising ocean bed, with funnelling shoreline and bottom contours, causes a further rise in the storm surge and may increase the surge to heights of 12 to 14 feet above normal sea level. This rise is also affected by the natural oscillation period of the body of water; that is, part of the surge is absorbed and part is reflected in much the same way as the astronomical tide. In Narragansett Bay, for example, the range of astronomical tide increases from 3.5 feet at the mouth to 4.6 feet at Providence. Both the storm surge and the astronomical tide increase in magnitude about one-third as they move up the bay.

There is another action which occurs when hurricane winds blow across very shoal waters of bays and estuaries as well as inland lakes. This is an actual tilting of the surface of the water, known as wind setup, caused by wind-generated surface currents. In deep water the surface currents are balanced by return currents below the surface, which offset the tendency of the water level to rise, but in shoal water bottom friction slows the return currents and water is driven upwards. A slope of 0.2 foot or more per mile of fetch may occur during a hurricane with an average water depth of 30 to 40 feet. In shallow Lake Okeechobee in Florida wind setup during passage of a hurricane may cause a slope of as much as 18 feet in 40 miles.

Finally, there is wave action on top of the hurricane surge. Hurricane waves breaking on exposed coasts reach heights of 25 feet or more from crest to trough. The amount of wave runup on a structure, that is, the height above the stillwater level reached by breaking wave crests, may be one or two times the wave height. Waves breaking on structures are limited in height by the depth of water at the toe of the structure; for example, the maximum wave height for a 10-foot depth is 8 feet.

3. *How high a hurricane flood should we design for?*

The measured high-water elevations on the New England coast range from about 6 to 16 feet above mean sea level, with high-water marks, which include wave action, reaching an elevation of 25 feet or more. Recorded high-water elevations give the first approach to a design flood.

Much more severe hurricane winds and lower barometric pressures have been recorded in the southern latitudes, as in Florida, than have been experienced in New England. Studies of the maximum storm and flood-surge possibilities in the New England area have not been completed.

A more thorough development of design elevations begins with Weather Bureau studies of maximum wind velocities in the wind field accompanying hurricanes. The Beach Erosion Board, with the assistance of the Texas A & M Research Foundation, has made calculations carrying the ocean surge to the coast and up estuaries, such as Narragansett Bay. Hydraulic model studies have also been of great value in the Narragansett Bay area.

For the design of protective structures the 1944 hurricane, a storm of unusual energy off Cape Hatteras, was transposed to a track over water and timed to strike at high tide. In this manner a design hurricane flood surge, including wind set-up, was derived with elevations 3 to 5 feet higher than experienced in the record flood of September 1938.

4. *Should we design for fresh water runoff coincident with a hurricane surge?*

The Weather Bureau studies shown that heavy rainfall is normally associated with great hurricanes. Warm, moisture-laden air is carried from the ocean over land by northeasterly winds in advance of a hurricane. Heavy precipitation is likely to occur, not only at the time the hurricane strikes, but also one to three days in advance of

FISHING VESSELS GROUNDED ON CROW ISLAND, NEW BEDFORD AND FAIRHAVEN HARBOR, DURING HURRICANE "CAROL," 31 AUGUST 1954. (Photo by *New Bedford Standard-Times.*)

the hurricane. Consequently, high river runoff and severe flooding can be expected at the same time.

An example of this situation was the hurricane flood of September 1938. Many of the rivers in New England overflowed their banks and caused heavy flood losses one day in advance of the hurricane while on other rivers, such as the Thames River above New London, Connecticut, fresh-water flooding occurred about the same time as salt-water flooding.

As a basis of design for Providence and Narragansett Bay the record rainfall in the September 1938 hurricane was transposed from

Connecticut. In the Providence area, this transportation resulted in a 24-hour storm rainfall of 9.5 inches. This is considerably less than the maximum 24-hour rainfall of 16 inches, near Westfield, for hurricane Diane (August 1955). It does not appear reasonable to assume that the maximum rainfall of "Diane," a slow moving hurricane without strong winds, could coincide with the maximum hurricane surge, which in New England is produced by rapidly moving storms.

Methods of Hurricane Protection

After gathering basic data on the frequency, cause, and potentialities of tidal flooding caused by hurricanes and other severe storms, consideration was given to a number of methods of reducing or preventing the damages incurred by such flooding. The considered methods, which vary widely in effectivness, cost, and application, may be divided into two groups or categories of protection. The first would include steps that can be taken to protect life and minimize damages without actually preventing the inundation of properties by sea water; the second, measures that would eliminate damages, in whole or in part, by protecting properties from the onslaught of hurricane waves and surges.

Among the methods in the first group, that can be initiated separately or together, are the following:

1. Warning services. The provision of improved warning services, giving sufficient advance notice as to where and when a hurricane will strike, is an important essential in the successful operation of practically all methods of reducing the terrifying impact of hurricanes along the coast. Timely issued warnings afford individuals an opportunity to remove valuables and seek safety on high ground before the arrival of hurricane tides.

2. Evacuation or flood-emergency programs. Included in this method of protection are programs that may be adopted by a community to provide for the orderly evacuation of persons from danger areas. Such programs would also contain plans for the provision of food and shelter during the period of the emergency. Also included under this heading would be programs established by private concerns setting forth definite steps to be taken to lessen the damage risk at the time of a hurricane. Programs of this latter nature would contain such measures as plans for the removal of goods and equipment to higher floor levels or entirely out of the tidal-flood area.

3. Zoning regulations. The enactment of zoning ordinances, preventing or restricting development in areas susceptible to flooding, would eliminate potential sources of damage in future hurricanes. However, revised zoning measures often tend to meet with strong opposition, especially when they are proposed for areas in which large investments in property have been made.

4. Modified building codes. Flood losses in future hurricanes can be reduced by modifying present building codes to require the construction of buildings less vulnerable to hurricane waves and tidal flooding. Several towns in New England now require that the first floors of new construction in the flood plain be at or above an established elevation.

The foregoing methods all have merit to some degree and can be effective in saving life and reducing damages. However, they are not the answer to the problem of preventing tidal flooding during a hurricane. Protection of a more positive nature, that is, protection that actually prevents the flooding of properties, must be considered for localities where severe damages have been experienced. Such protection may consist of local measures, adopted for a single building or group of buildings, or a comprehensive plan of protection for the entire area.

Local protection would include measures of the following nature:

1. The construction of flood walls around individual properties;
2. The flood-proofing of structures;
3. The permanent closure of windows and other openings exposed to flood waters or the provision of means for the temporary closure of such openings;
4. The installation of valves or gates in pipe lines to prevent the backup of flood waters; and
5. The installation of pumps to control seepage and interior drainage.

There are a number of instances where local protective works of the above nature have been installed by commercial establishments, industrial concerns, and even individual home owners in Providence, Rhode Island, and New Bedford, Massachusetts, as well as in other areas of New England, since the occurrence of hurricane Carol on August 31, 1954. The installation of such measures, however, can be costly. Several entail the loss of production by reason of necessitating partial or complete shutdown of plant operations. It appears inconceivable that works of a local nature could be generally adopted for the protection of a large number of properties in a flooded area without proving uneconomical. In such cases, consideration should be given to the construction of protection works more comprehensive in scope, such as the following:

1. Barriers or dams. The construction of barriers or dams, with gated openings, will prevent tidal flooding during a hurricane by affording complete closure of a waterway. The gated opening may be either in the nature of conduits to pass the flow in normal times or clear openings of sufficient width to accommodate the needs of navigation. The construction of barriers with ungated openings will effect a reduction in the volume of tidal flow entering a waterway, and, thereby, the elevation of flooding above the barrier at the time of a hurricane.

2. Walls or dikes. The construction of walls or dikes along the shore prevents the inundation of properties by holding back the tidal-flood waters. This type of protection has been employed to prevent river flooding at a number of localities in New England, such as Hartford, Connecticut, and Springfield, Massachusetts, on the Connecticut River.

3. Raising of beaches and/or dunes. Possibilities exist for providing protection against tidal flooding by raising and widening existing beaches and dunes. This method of protection is being considered in current studies of hurricane flood problems at a number of areas along the coast.

4. Breakwaters. The construction of breakwaters will reduce the height of storm waves, and, consequently, the damage that such waves cause when they break against structures along the shore. This type of protection, however, is only partially effective since it does not lower the stillwater level of flooding.

Barriers with gated openings, supplemented by wall and dike protection, are included in the recommended plans for protection at Providence, Rhode Island and New Bedford, Massachusetts. Barriers with ungated openings are being considered in plans now under study for reducing flood heights in Narragansett Bay.

Tidal-Flood Protection for the New Bedford Area

Extent of Flood Problem. The three most severe hurricanes to strike the New Bedford area in the past 50 years were those of September 21, 1938, September 14, 1944, and August 31, 1954. The hurricanes of 1938 and 1954 both struck at a time nearly coincident with gravitational tide, while the hurricane of 1944, although a very

This Photo Shows the Parking Area of One of the Large Industrial Plants on the West Bank of the Acushnet River Shortly After the Peak of Tidal-Flooding in Hurricane "Carol" Was Reached on 31 August 1954. Similar Damage Was Experienced at a Number of Other Large Plants in New Bedford During This Hurricane. (Photo courtesy cf Aerovox Corporation.)

intense storm, struck at a time of low tide and, consequently, caused less severe flooding. Tidal flooding in New Bedford, Fairhaven, and Acushnet, Massachusetts, in the 1938 and 1954 hurricanes, reached elevations of 12.5 and 11.9 feet above mean sea level, respectively, or 10.7 and 10.1 feet above mean high water, and at those elevations inundated about 1700 acres. This figure excludes the Sconticut Neck and West Island areas of Fairhaven which are to be the subject of future studies. The flooded area is shown on Figure 1. It is interesting to note that if the level of flooding in 1938 had been about one foot higher, the flood waters from Clark Cove would have joined with flooding in the main harbor and, thereby, temporarily made an island of Clark Point. Similarly, flooding from the Harbor View area of Fairhaven would have joined with that in the harbor and made an island of the high ground north of Fort Phoenix.

The most damaging storm in the New Bedford-Fairhaven area, from a dollar viewpoint, was the hurricane of 1954 which caused tidal-flood damages amounting to $26,200,000. (See Figure 1.) Of this amount, $23,370,000, or nearly 90 percent of the total, was sustained in the industrial city of New Bedford where the hurricane tide inundated about 1,000 acres along the entire 10-mile length of the city's waterfront. In this flooded area are approximately 60 industrial plants, employing 20,000 people, which experienced damages amounting to nearly $19,000,000, or about 80 percent of the total damage in New Bedford. The distribution of 1954 flood losses in New Bedford, by areas, is as follows:

Area 1—Above Coggeshall Street bridge	$7,060,000
Area 2—Between Coggeshall Street bridge and the New Bedford-Fairhaven (Route 6) bridge	$5,060,000
Area 3—Between Route 6 bridge and Clark Point	$8,430,000
Area 4—Clark Cove	$2,820,000

The distribution of the remaining damages of $2,830,000, sustained in the towns of Acushnet and Fairhaven, is as follows: $680,000 in the area above the New Bedford-Fairhaven bridge; $1,740,000 between the New Bedford-Fairhaven bridge and Fort Phoenix and Pope Beach.

In order to compare preventable losses with the cost of considered plans of protection, estimates were made of the recurring losses, based on 1956 prices, that would be experienced in the event of future hurricanes of differing intensities. (See Figure 2.) In a recurrence of the flooding sustained in 1938 and 1954, damages would amount to $32,970,000 and $27,340,000, respectively. With a flood stage equal to that experienced in the 1944 hurricane, or 3.7 feet below the 1954 flood stage, the damages would be relatively minor,

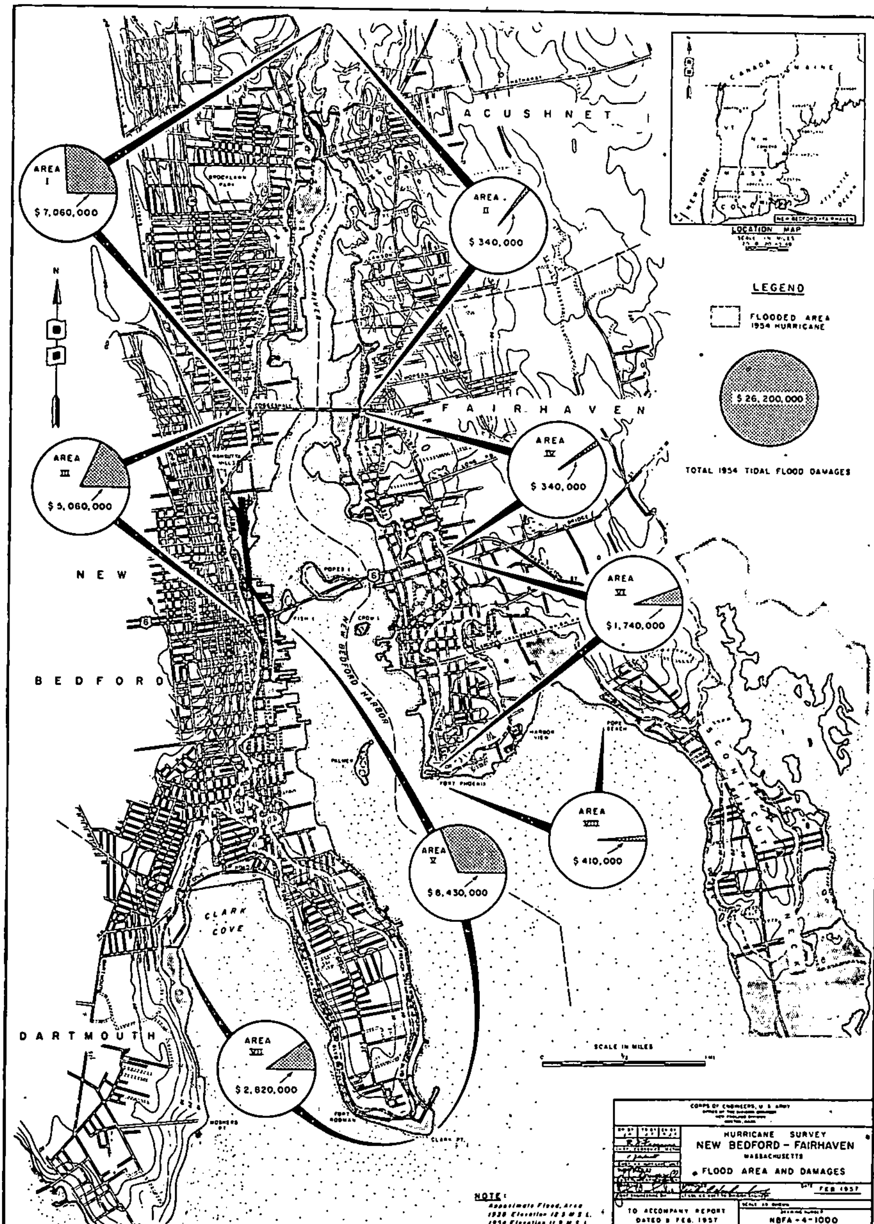


FIG. 1.—FLOOD AREA AND DAMAGES, NEW BEDFORD–FAIRHAVEN, MASS.

amounting to about $1,550,000. The hurricanes of 1938, 1944 and 1954 were the greatest to hit the area in the past 50 years and a repetition of these same three hurricanes in the next 50 years would result in total damages of nearly $62,000.000. In the event of the occurrence of a design storm, which would cause flooding to an ele-

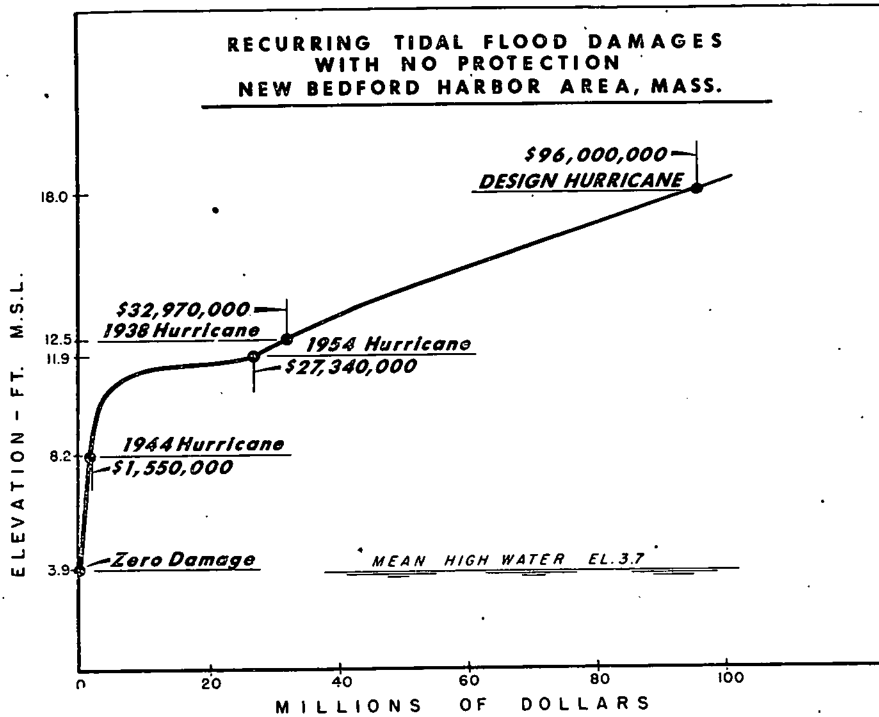


FIG. 2.

vation 18 feet above mean sea level, or 5.5 feet above the 1938 flood level, damages would amount to $96,000,000.

The flood problem in the New Bedford area, based on the extent and character of the flooded area, is one of finding a means of providing protection to a thickly settled industrial and urban area and to provide this protection with a minimum amount of disruption to existing facilities and at a cost that can be economically justified by the benefits obtained.

The first step in the development of a plan of protection for the

New Bedford area was to determine the required height of protective structures. The maximum depth of flooding experienced by properties in the area was about 8.5 feet in the 1938 hurricane; about 8 feet in the 1954 hurricane. These depths represent flooding to elevations approximately 10 feet above the predicted astronomical tide for the time when peak flooding occurred. With the occurrence of a design hurricane, this surge of 10 feet would be increased to 15 feet, and, should it occur coincident with a spring tide, cause flooding to an elevation of 18 feet above mean sea level. In addition, some increased height of protection must be allowed for the more exposed locations in order to minimize overtopping by the high waves generated by the hurricane winds. To meet this requirement, a 4-foot allowance, predicated on an 8-foot design wave, was adopted, which, when added to the design-flood level, gave a maximum top elevation of 22 feet above mean sea level for protective works. This elevation is 9.5 feet above the 1938 flood level. Although the structures would be subject to overtopping by the highest waves, they have been designed to take this overtopping without failure.

Considered Protection Plans for New Bedford Area. Consideration was given to a number of plans for protective works that would prevent losses from tidal flooding in future hurricanes. Five of the plans, designated "A" to "E," provided for protection by means of dikes, walls, and barriers at sites between the Coggeshall Street bridge and the New Bedford-Fairhaven bridge. Although the cost of each of these five plans could be justified on the basis of preventable damages, they would provide protection for only about one-quarter to one-half of the flooded area. If Plan "A," providing a barrier at Coggeshall Street, had been in operation at the time of the 1954 hurricane, it would have reduced the experienced damages by about 28 percent. Similarly, Plan "E," calling for a barrier structure just below the New Bedford-Fairhaven Bridge, would have reduced the losses by about 49 percent. On the other hand, Plan "F," the selected plan of protection, described below, would have experienced about 95 percent of the total damages in 1954.

Consideration was also given to a plan providing for a barrier between Clark and Sconticut Points which would afford protection for a major portion of the local area subject to hurricane tidal flooding. To secure the needed degree of protection, the project would require either a wide, gated opening for navigation or a relatively narrow ungated opening supplemented by a sufficient number of sluices to effect a reduction in velocities through the navigation opening. The costs for either one of the alternates would be high and could not be justified.

Selected Plan of Protection—Plan "F." Plan "F," shown on Figure 3, was selected as the most feasible plan of protection for the New Bedford area. It provides economical protection to the most important damage centers in the flooded area. The alignment of structures in the plan involves a minimum amount of land taking since much of the required land is owned by the city of New Bedford and the town of Fairhaven. In addition, borings taken during the course of the study indicate that the site of the harbor crossing is a most favorable one from a geological standpoint.

The largest and most important of the three principal structures in the plan is a barrier across New Bedford Harbor in the vicinity of Palmer Island. Supplemental dike and wall protection is provided in the Clark Cove area of New Bedford, and in Fairhaven, to prevent flanking of the main barrier.

1. *Main harbor barrier.* The harbor barrier, shown on Figure 4, consists of 4,430 feet of earth-fill dike, with rock faces and toes, extending across the main harbor from the foot of Gifford Street in New Bedford to the south end of Palmer Island and then continuing east across the harbor to high ground in Fairhaven, northeast of historic Fort Phoenix. It will have a top elevation of 22 feet above mean sea level, a top width of 20 feet, and side slopes of 1 on 2.5. In section (See Figure 4) the barrier will consist of two rock toes and an earth-fill center, with rock cover. To withstand the attack of hurricane waves, 3- to 6-ton derrick stone will be used on the outer face.

A gated opening, 150-feet wide, is included in the section of the barrier between Palmer Island and Fairhaven to permit continued navigation in the harbor. The maximum current in this opening during the rise and fall of a spring tide has been determined to equal approximately two knots. This maximum current, which will be experienced only upon a few occasions each month, and then only for short periods of time, is not considered to be excessive from a navigation viewpoint.

A gated conduit is provided in the section of the barrier between the New Bedford shore and Palmer Island to permit emergency emptying of the pool that will form behind the barrier when the gates

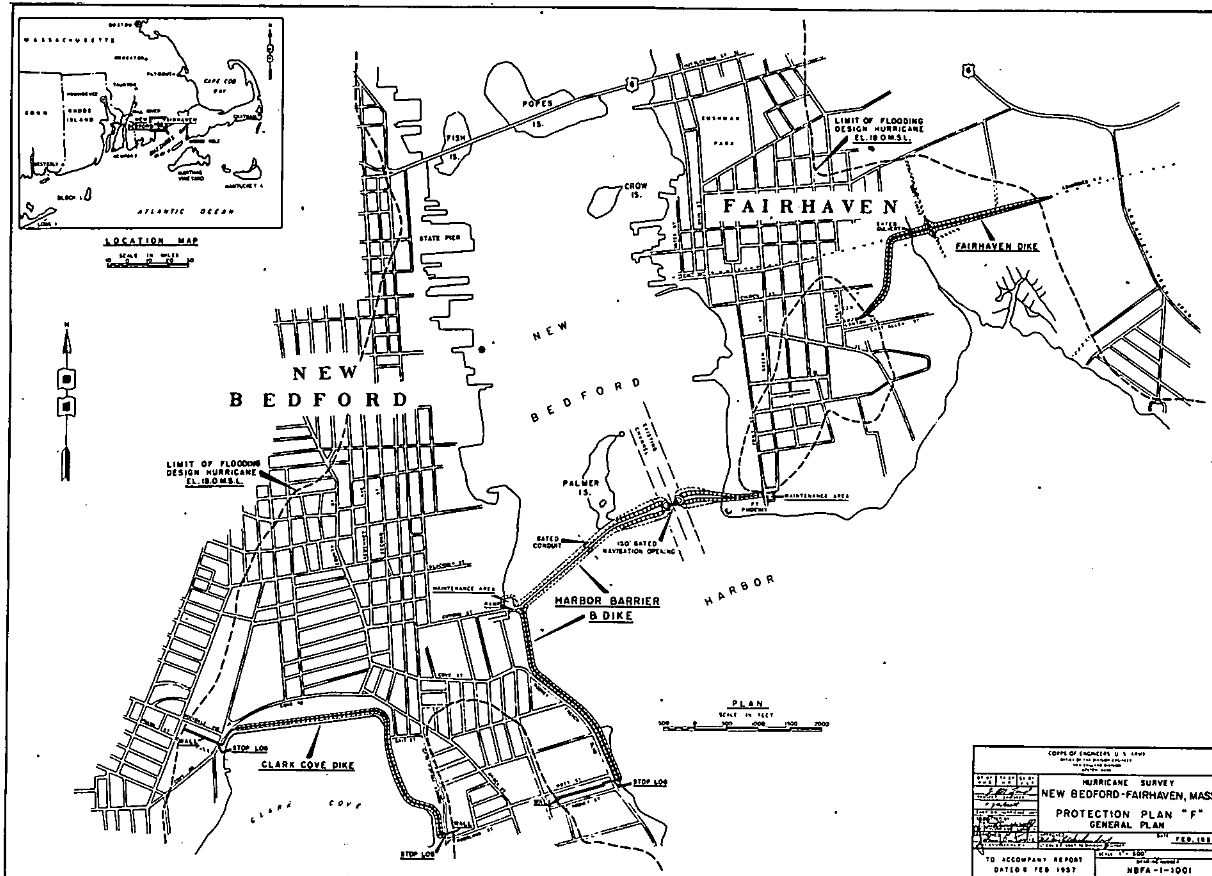


FIG. 3.—PROTECTION PLAN "F", NEW BEDFORD–FAIRHAVEN, MASS.

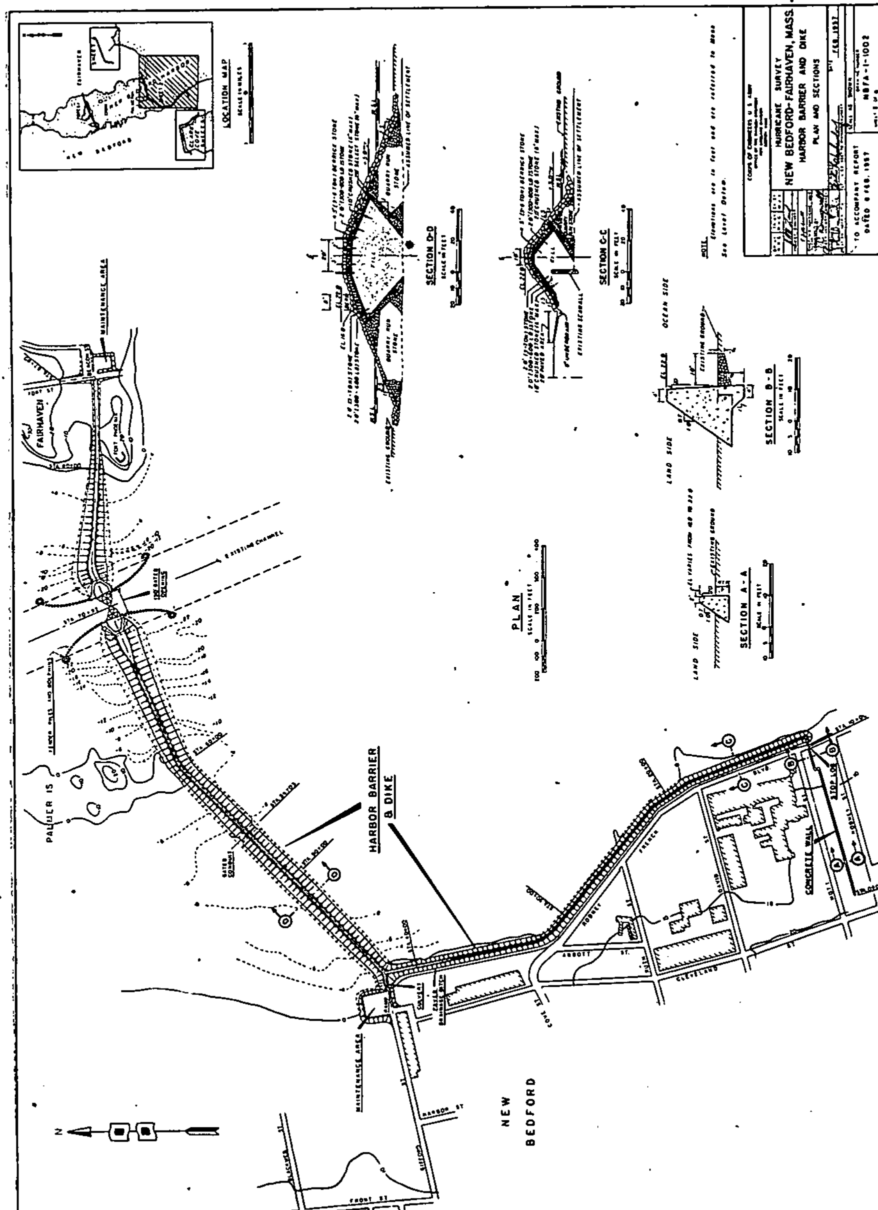


FIG. 4.—HARBOR BARRIER AND DIKE, PLAN "F".

in the navigation opening will be closed at the time of a hurricane. It will also serve to create a circulation of tidal flow on the west side of Palmer Island.

A dike extension to the barrier, constructed of earth fill with rock facing, is provided along Rodney French Boulevard in New Bedford, from the foot of Gifford Street to just beyond the foot of Mott Street, a distance of about 3,100 feet. The dike has a top elevation of 22 feet above mean sea level, the same as the main harbor barrier, and a width of ten feet. A concrete gravity wall, running 1,100 feet to the west from the southerly end of the dike, completes closure to high ground. A stoplog opening is provided at Rodney French Boulevard.

Details of the proposed sector gates are shown on Figure 5. Each gate has a radius of 90 feet, a central angle of approximately 60°, a total height of 61 feet, and a weight of 516 tons. The gate sills will be at an elevation of 39 feet below mean sea level, or 37.2 feet below mean low water. This sill elevation permits future deepening of the present navigation channel by 5 feet, plus an additional allowance of two feet for overdepth dredging, without requiring any modification to the gates. Normally, the gates will be kept in an open position with each gate set into a recess in its abutment. They will be closed only when a hurricane threatens the area with tidal flooding.

2. *Clark Cove dike.* Protection in the Clark Cove area, shown on Figure 6, consists of an earth-fill dike, with rock faces, extending along the head of the cove for a distance of 2,200 feet, then south along the east shore of the cove for 2,400 feet. This dike has a top elevation of 22 feet above mean sea level, a top width of 10 feet, and side slopes of 1 on 1.5. In cross-section, the dike is similar to the main harbor barrier with the exception that no rock toes are employed in its construction. Closure to high ground at the west end is accomplished by 1,100 feet of concrete gravity wall. A second section of wall, 200 feet long, effects closure at the east end. Stoplog structures are provided at the crossing of Cove Street and at the crossing of Rodney French Boulevard.

3. *Fairhaven dike.* The Fairhaven dike, shown on Figure 7, starts at high ground near the foot of Lawton Street in Fairhaven, south of the Atlas Tack Company, and runs northerly, around the Tack Company property, for a distance of about 1,250 feet to an abandoned railroad right-of-way now owned by the town. It then

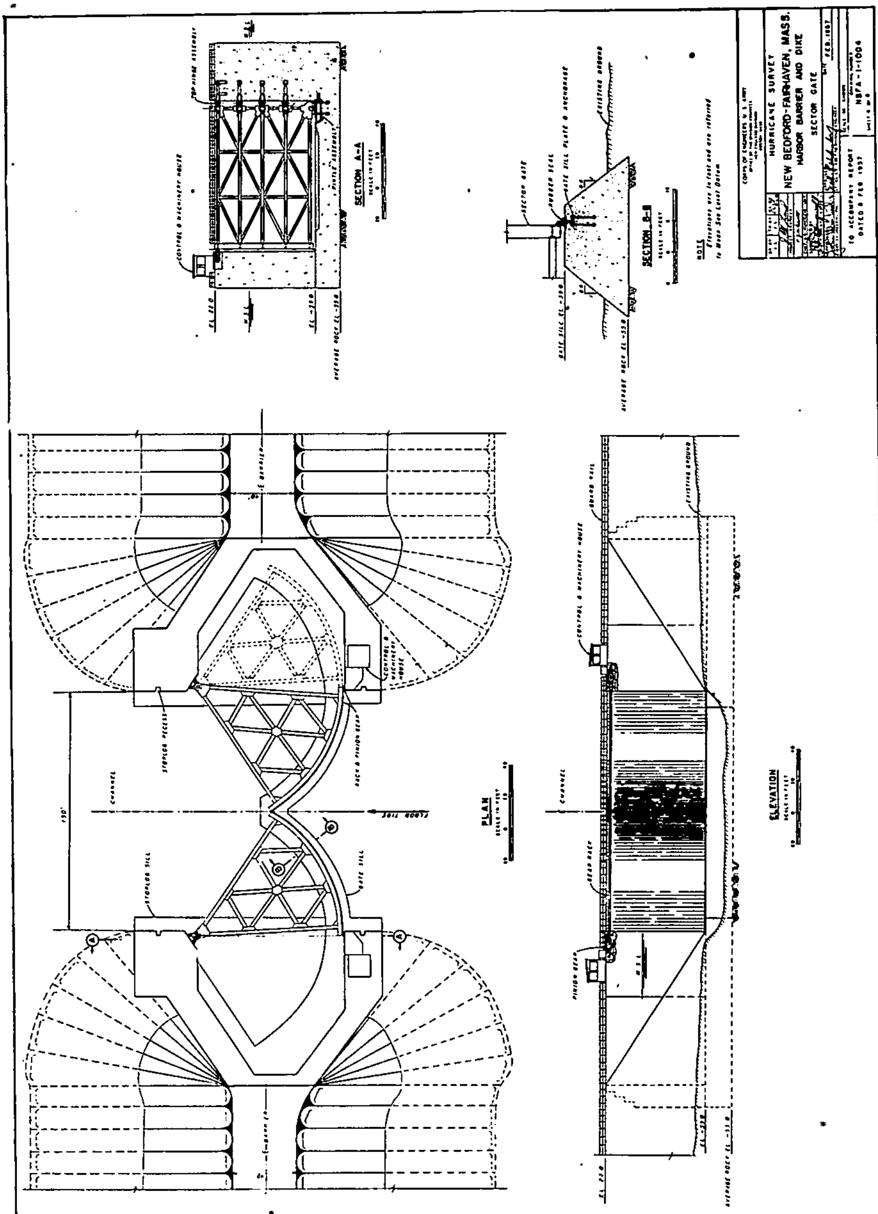


FIG. 5.—SECTOR GATE, HARBOR BARRIER AND DYKE, PLAN "F".

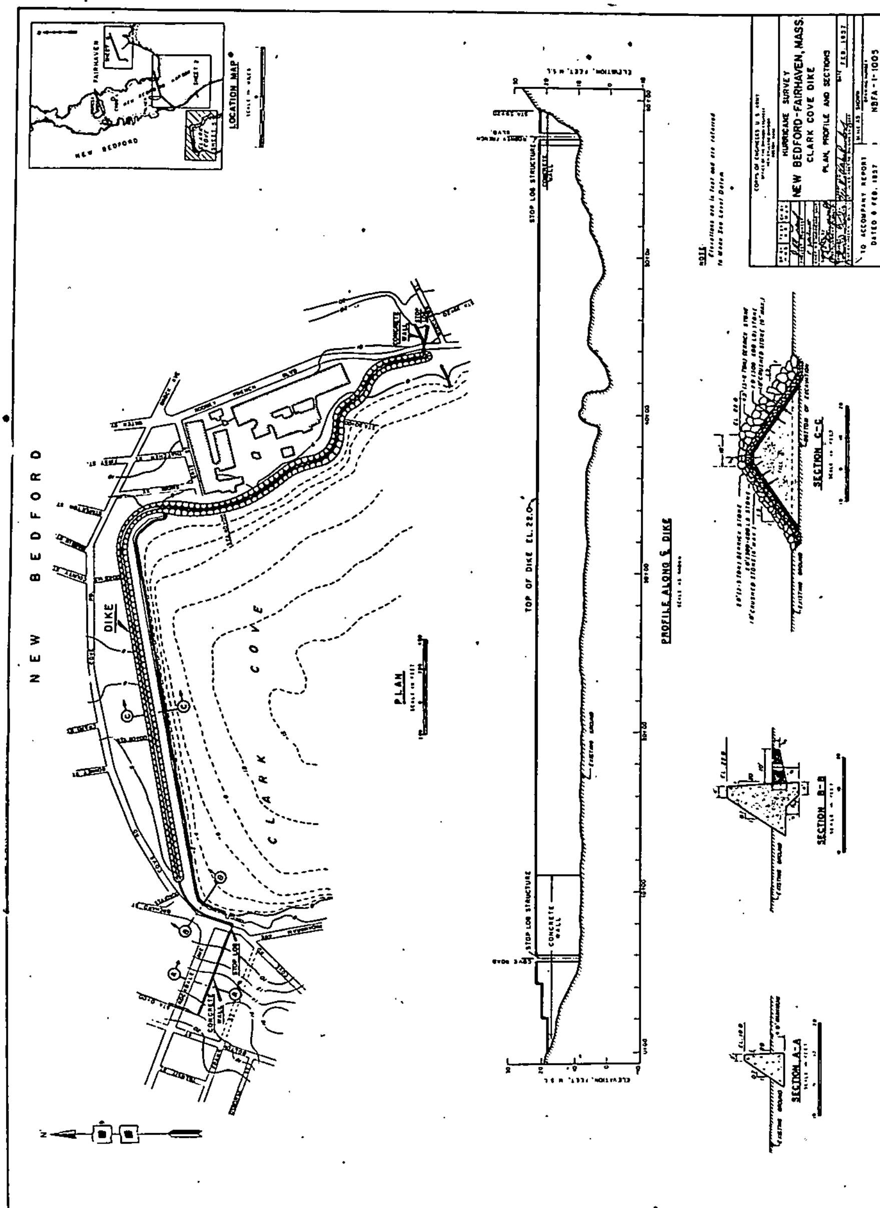


FIG. 6.—CLARK COVE DYKE, PLAN "F".

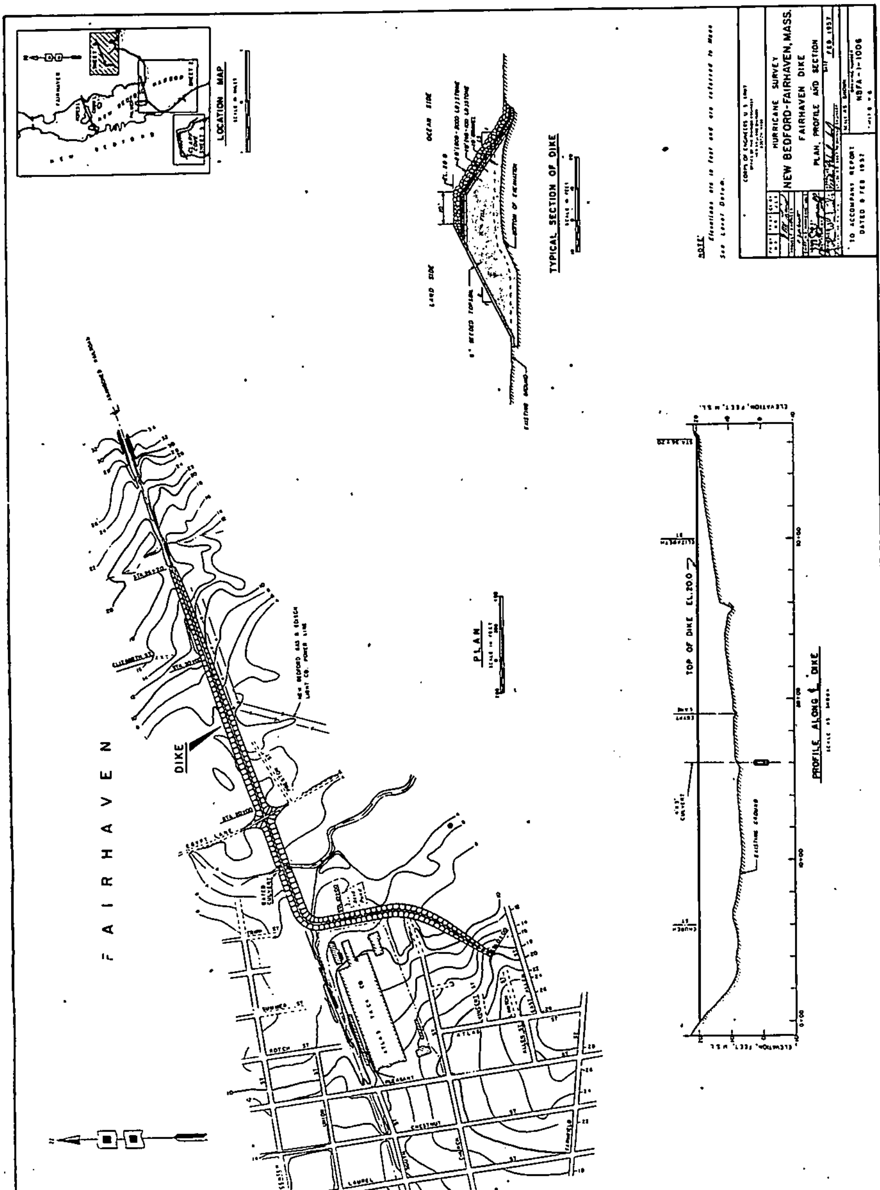


FIG. 7.—FAIRHAVEN DYKE, PLAN "F".

continues east along the right-of-way for about 2,400 feet to high ground. The dike consists of earth fill with rock facing on the top and on the seaward slope, and seeded topsoil on the inner slope. This dike has a top elevation of 20 feet above mean sea level, a top width of 10 feet, and side slopes of 1 on 1.5 and 1 on 2. Owing to its distance back from the shorefront, this dike will be subjected to less wave action than the other two structures in the plan. For this reason, its top elevation has been set two feet lower.

4. *Sewer and drainage modifications.* Sewerage facilities in New Bedford include a main interceptor sewer, with maximum dimensions of 84 x 92 inches, running south along the east shore of Clark Cove to a submerged outfall extending 2,300 feet into Buzzards Bay from the end of Clark Point. Overflow lines divert excess flow at times of heavy rain into the Acushnet River, the main harbor, and Clark Cove. In order to prevent the backup of hurricane tides in the main interceptor a sluice gate will be installed in the line where it passes under the east flood wall of the Clark Cove protection. A second sluice gate is provided near the intersection of Second and Blackmer Street and an 84-inch line will be constructed down Blackmer Street to divert the flow from the main interceptor to the pool above the harbor barrier at the time of a hurricane.

5. *Ponding and pool buildup.* During a hurricane, when all openings through the barrier and dikes will be closed, ponding will occur behind the protective works. The amount of this ponding will depend upon the amount of runoff from the Acushnet River and local area and the amount of overtopping by hurricane waves. An antecedent rainfall of about 13 inches in 55 hours was adopted for estimating the peak runoff to be anticipated from the Acushnet River when the navigation gates are closed. This rainfall intensity equals the record rainfall at Mansfield, Massachusetts, during hurricane Diane (August 1955) which caused disastrous flooding in the Naugatuck and other New England river basins. Mansfield is located in the Wading River. The Wading River was selected because of its proximity to the New Bedford area; also because its watershed is similar in characteristics to that of the Acushnet River.

A design rainfall of 8 inches in 24 hours was adopted for the rainfall coincident with a design hurricane. The occurrence of this design rainfall coincident with a design hurricane is considered to be a rather severe assumption.

Under the extreme conditions of a design rainfall coinciding with a design hurricane, no damage would be caused by ponding behind the harbor barrier and then only in the event that the water surface of the pool was at or above an elevation of mean sea level when the gates were closed. In the Clark Cove area, negligible ponding would be experienced in a recurring 1938 hurricane. Some minor ponding of runoff would be experienced in a recurring 1954 hurricane. With conditions of a design hurricane accompanied by design rainfall, ponding from local runoff and from overtopping by waves would be sufficient to cause minor overflow to the main harbor pool. However, the combination of factors contributing to this condition would be of very rare occurrence. The degree of ponding to be anticipated was not considered to present a serious enough threat to warrant the cost of providing pumping facilities.

Economic Justification of Plan "F." Plan "F," the recommended plan, would afford protection to an area of over 1,400 acres in New Bedford, Fairhaven, and Acushnet. The properties in this area would be afforded complete flood protection in the event of future hurricanes equal to those experienced in 1938 and 1944. Protection would be practically complete in the event of a recurring 1954 hurricane with only a relatively small amount of residual damage, in an amount of about $10,000, being experienced in the Clark Cove area by reason of shallow ponding behind the dike, as indicated in the preceding paragraph. In a design hurricane, which would cause damages of nearly $92,000,000 if no protection is provided, the plan would reduce the damages by nearly $88,000,000, or nearly 95 percent, leaving a residual damage of only $4,000,000.

The annual benefits from the project are estimated at $988,000. This amount equals $944,000 from a reduction in tidal-flood damages plus $44,000 from the elimination of "scare costs." The term "scare costs" is one that has been applied to the costs incurred by local industrial and commercial establishments for undertaking temporary protective measures upon the receipt of a hurricane warning. These are costs that can be incurred even though a hurricane fails to strike the area.

The total first cost of Plan "F" is estimated at $17,200,000. Annually, this represents a cost of $691,000 which includes interest on the investment, amortization over a 50-year period, and $75,000 a year for operation and maintenance. A comparison of total annual benefits of $988,000 with annual costs of $691,000 gives a benefit to cost ratio of 1.4 to 1.0 signifying an economically justifiable project.

Tidal-Flood Protection for the Narragansett Bay Area

Extent of Flood Problem. Hurricane Carol, August 31, 1954 caused the loss of 19 lives and over $90,000,000 damages in the Narragansett Bay area and on the Rhode Island coast.

The 1938 hurricane was much more severe with flood levels about one foot higher. Two hundred and sixty-two lives were lost in the State of Rhode Island alone. Although no accurate evaluation of experienced 1938 damages is available, it is estimated that a recurrence of the 1938 flood stages, at 1956 price levels, would cause losses of about $120,000,000, of which nearly $8,000,000 would occur within the Massachusetts portion of the Narragansett Bay area, as shown in Figure 8.

The depths of flooding in 1938 ranged from about 11.0 feet above mean sea level at Newport to 16.0 feet above mean sea level at Providence. The business center of Providence was flooded to depths of from 6 to 8 feet over city streets. At these elevations of flooding, approximately one-third of the total tidal-flood damages, or seventy percent of the damages in the area above Conimicut Point, are experienced in the business center of the city of Providence.

Plans for Protection. For the protection of the city of Providence and the Narragansett Bay area, at least 15 plans involving 25 locations for hurricane barriers were proposed soon after the 1954 hurricane. The proposals, which were made by private engineering firms, State and municipal agencies, and other interested parties, were presented in sufficient detail to merit careful examination and review. After engineering studies had been made of the better plans, a two-unit solution of the problem was recommended as follows:

a. For the protection of the business center of Providence, the construction of a concrete barrier across the Providence River at Fox Point in Providence.

b. For the general protection of the Narragansett Bay area, the construction of 3 rock-fill barriers in the East and West Passages of Lower Narragansett Bay and across the Sakonnet River at Tiverton.

Fox Point Barrier Protection for the City of Providence. This structure would consist of a concrete gravity dam, about 1,100 feet

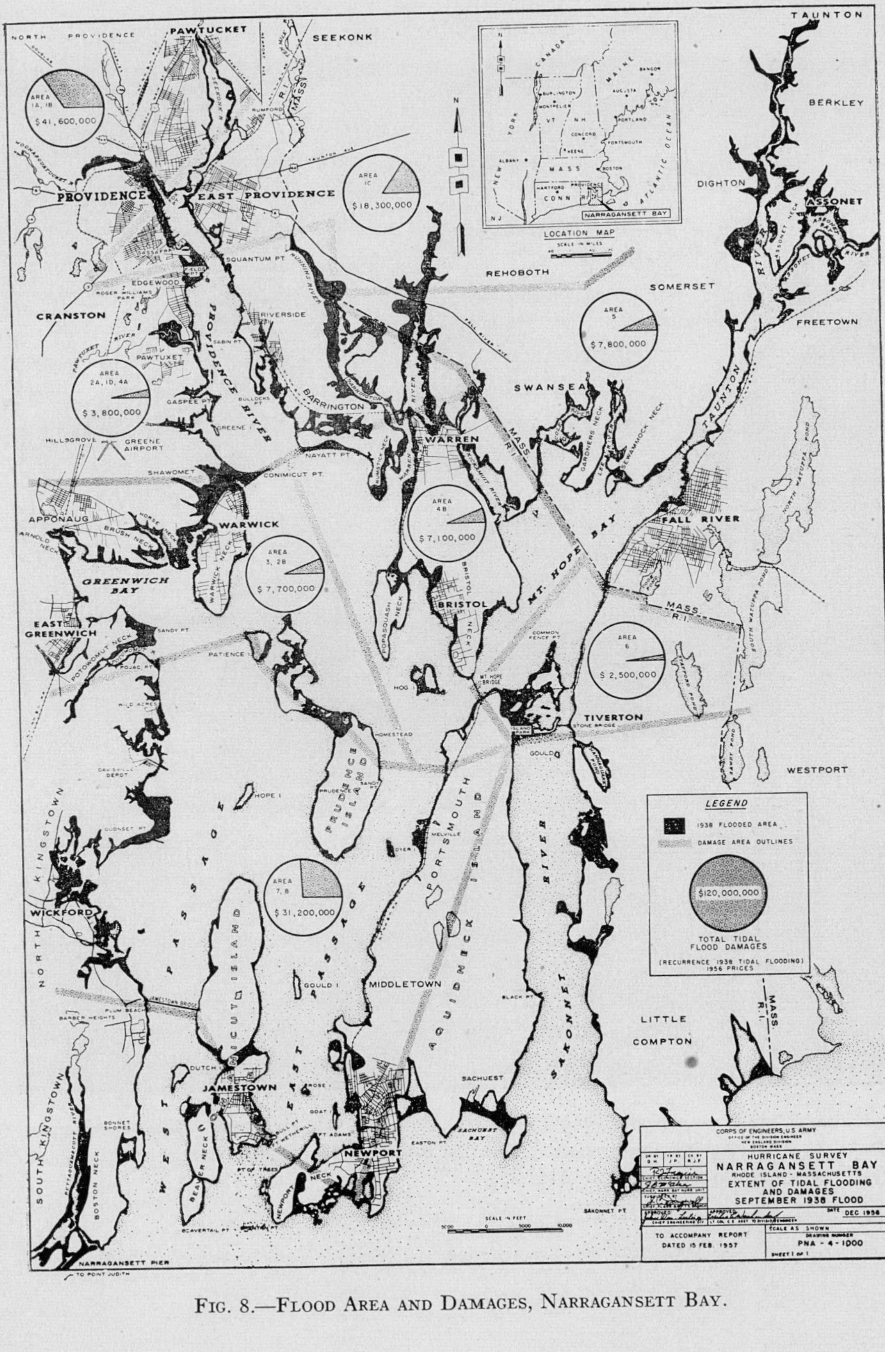
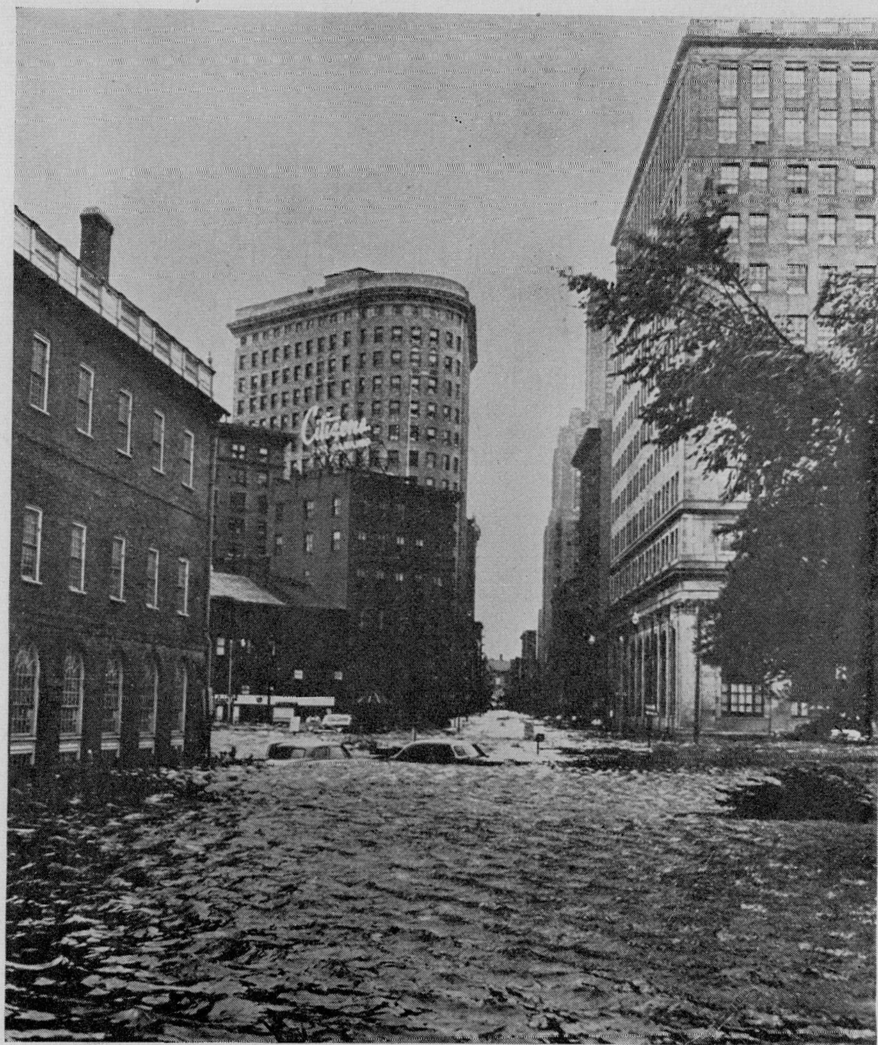


FIG. 8.—FLOOD AREA AND DAMAGES, NARRAGANSETT BAY.



Flood Waters of Hurricane "Carol" (August 1954) Receding from Center of Business District in Providence. Waters Rose as High as Eight Feet at Peak of Flood. (Photo by Dennis A. Murphy) long, extending across the Providence River from Henderson Street to Fox Point. Included in the barrier would be 4 sluice gates, a pumping station, and a 37-foot wide deck at elevation 12.5 feet above mean sea level for wharfage or highway use. Reinforced concrete walls, extending from each end of the structure, would tie into high ground. (See Figures 9 and 10.)

The dam would be supported on piles driven to approximately 60 feet below mean sea level. Borings showed that foundation conditions consist of variable silts, sands, and gravels overlaid by a heavy deposit of organic silt.

The barrier would have a top elevation of 22.5 feet above mean sea level. This height of protection represents an elevation of 6.8 feet above the measured stillwater level of flooding in Providence in 1938, or 3.8 feet above the level of the design flood.

The sluice gates, each 20 by 24 feet, would be of drop type. When open, they would pass normal river and tidal flow, including full flood runoff in the Providence River from design rainfall, and, when closed, would prevent the entry of tidal-flood waters in the bay.

A pumping station would contain 5 electrically-driven 120-inch diameter pumps having a combined discharge of 8,000 cubic feet per second at a differential head of 22 feet. These are the largest commercially manufactured pumps, each being driven by a 6,000 horsepower motor. In the event of a design hurricane surge coinciding with design runoff, the pumping station could reduce the elevation of the pool behind the barrier to 3 feet below mean sea level.

A sheet piling canal, located at the west end of the barrier, would provide about 1,300 cubic feet per second of cooling water for the generating stations of the Narragansett Electric Company.

The total first cost of the Fox Point project is estimated at $16,500,000.

General Protection for Narragansett Bay

1. *East Barrier.* This structure, consisting of 3,200 feet of quarry-run stone core, with heavy derrick stone cap and facing, would extend across the East Passage at Newport. (See Figure 11.) It would have a top elevation of 22 feet above mean sea level, a top width of 20 feet, and side slopes of 1 on 2. It would be in a water depth of 165 feet and have a maximum base of more than 700 feet. A navigation opening, 1,000 feet wide and 50 feet deep at mean low

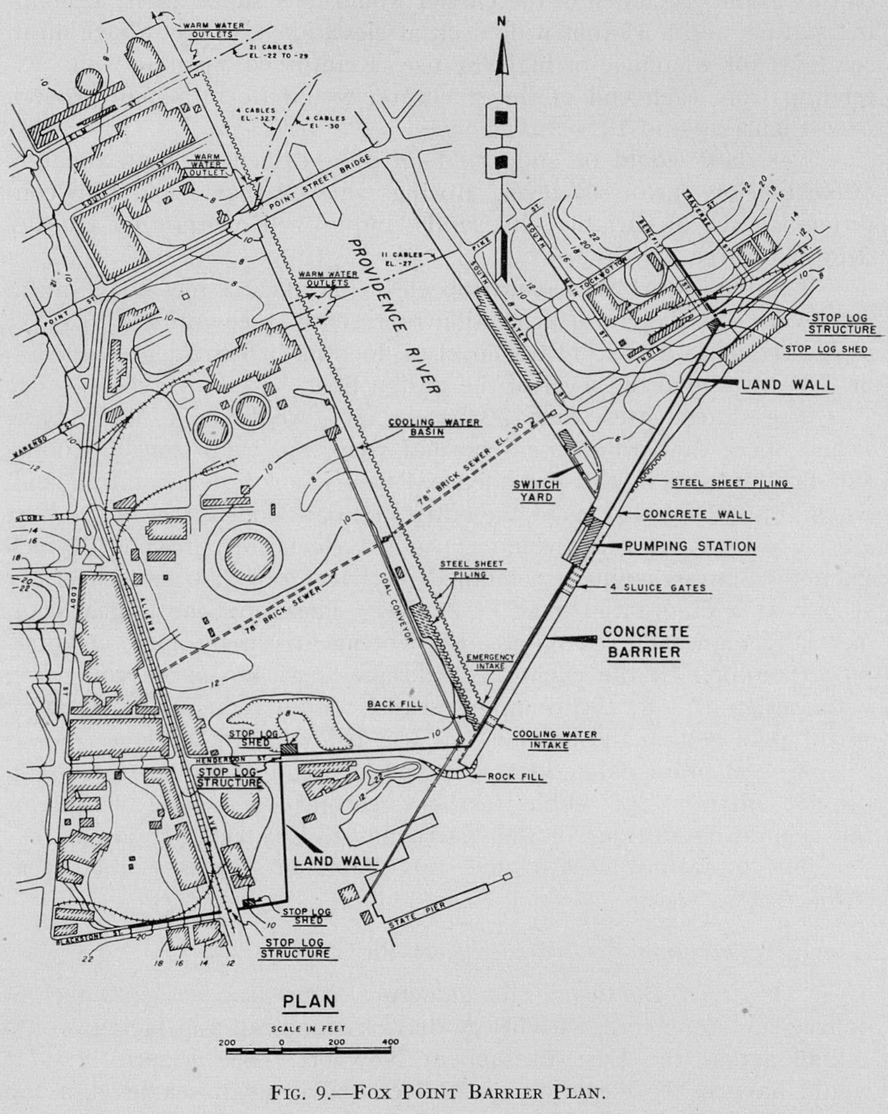


Fig. 9.—Fox Point Barrier Plan.

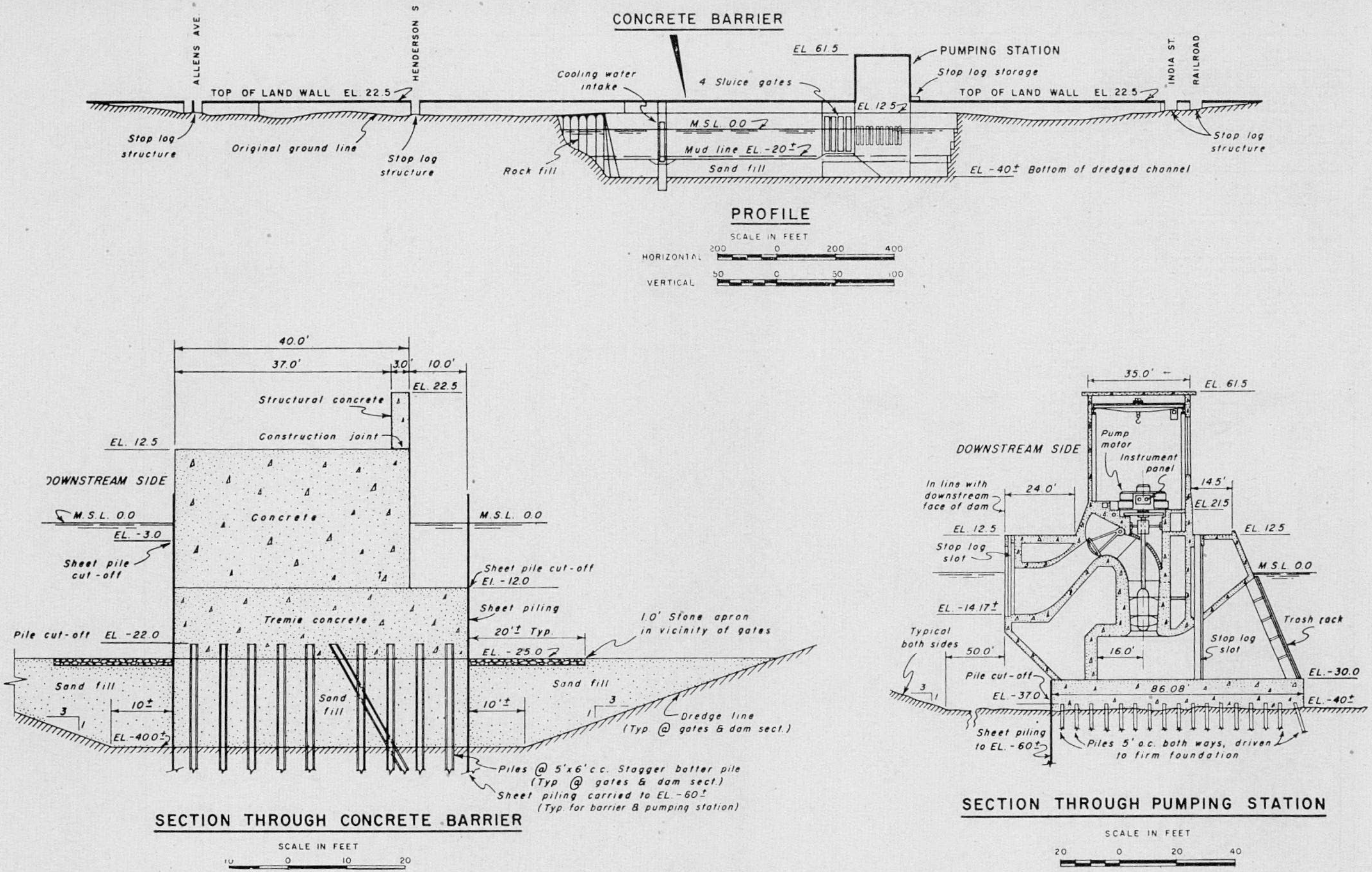


FIG. 10.—FOX POINT BARRIER, PROFILE AND SECTIONS.

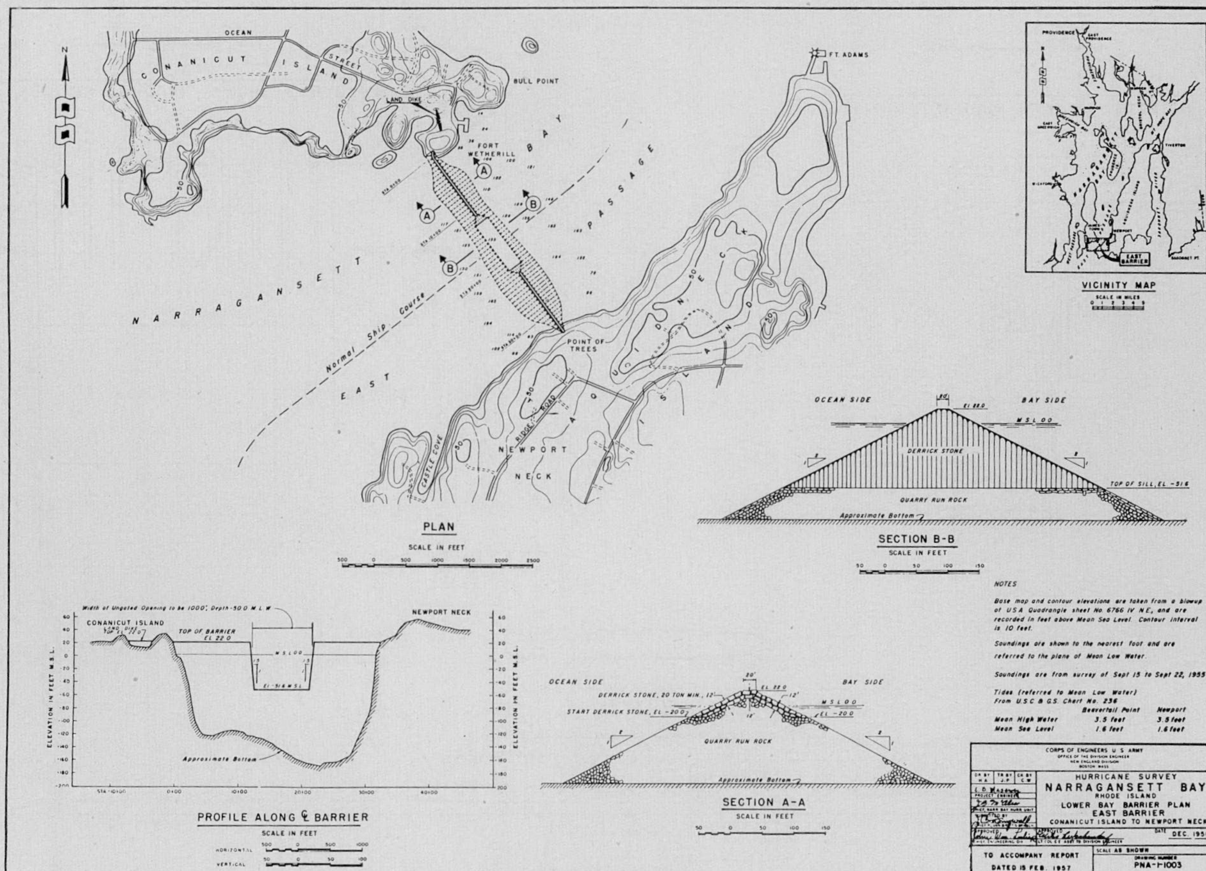


FIG. 11.—LOWER BAY BARRIER PLAN, EAST BARRIER.

water would be included in the barrier where it crosses the existing navigation channel.

2. *West Barrier.* The West Barrier, 7,100 feet in length, consisting of the same general material as the East Barrier, would cross the West Passage about 600 feet south of the Jamestown Bridge. (See Figure 12.) A navigation opening, 400 feet wide and 40 feet deep at mean low water, would be centered on the existing ship channel or navigation span of the Jamestown Bridge. On Conanicut Island, a land dike, with rock facing on the seaward slope, would be constructed across Round Swamp by raising an existing highway to elevation 22 feet above mean sea level.

3. *Tiverton Barrier.* This structure, having a total length of 9,500 feet, would consist of an earth-fill rock-faced barrier across the Sakonnet River, at Old Stone Bridge, with dike extension, consisting of earth fill with rock facing on the seaward slope, along the shorelines of the Island Park and Tiverton areas. (See Figure 13.) A gated opening, 100 feet wide and 30 feet deep below mean low water, would be included in the structure. Closure of the opening would be accomplished by sector gates similar to those designed for the New Bedford project. Owing to the fact that wave action is less severe in the Sakonnet River than in Lower Narragansett Bay, the barrier has been designed with a top elevation of 20 feet above mean sea level and a top width of 15 feet.

The Lower Bay barriers, as described, are based on preliminary studies. Completion of detailed design studies requires further investigation of the effect of the barriers on navigation—principally with respect to Naval interests—pollution, and fisheries. Final designs may provide larger navigation openings, and, in the West Barrier, the addition of navigation gates and sluice gates. Further investigation is also required of foundation conditions in the East Passage. Preliminary investigation, made by seismic methods and by a Kulenberg Corer which penetrated less than 10 feet, indicates the possibility of poor foundation conditions in the 165-foot depth of water.

Preliminary estimates of the cost of the Lower Bay barrier plan are between \$69 and \$109 million. The smaller estimate allows for an average settlement of 20 feet for the East Barrier. If foundation conditions in East Passage prove more unfavorable, and if navigation gates or sluice gates are required in the West Barrier, the cost would be much greater. This is the basis of the larger preliminary estimate.

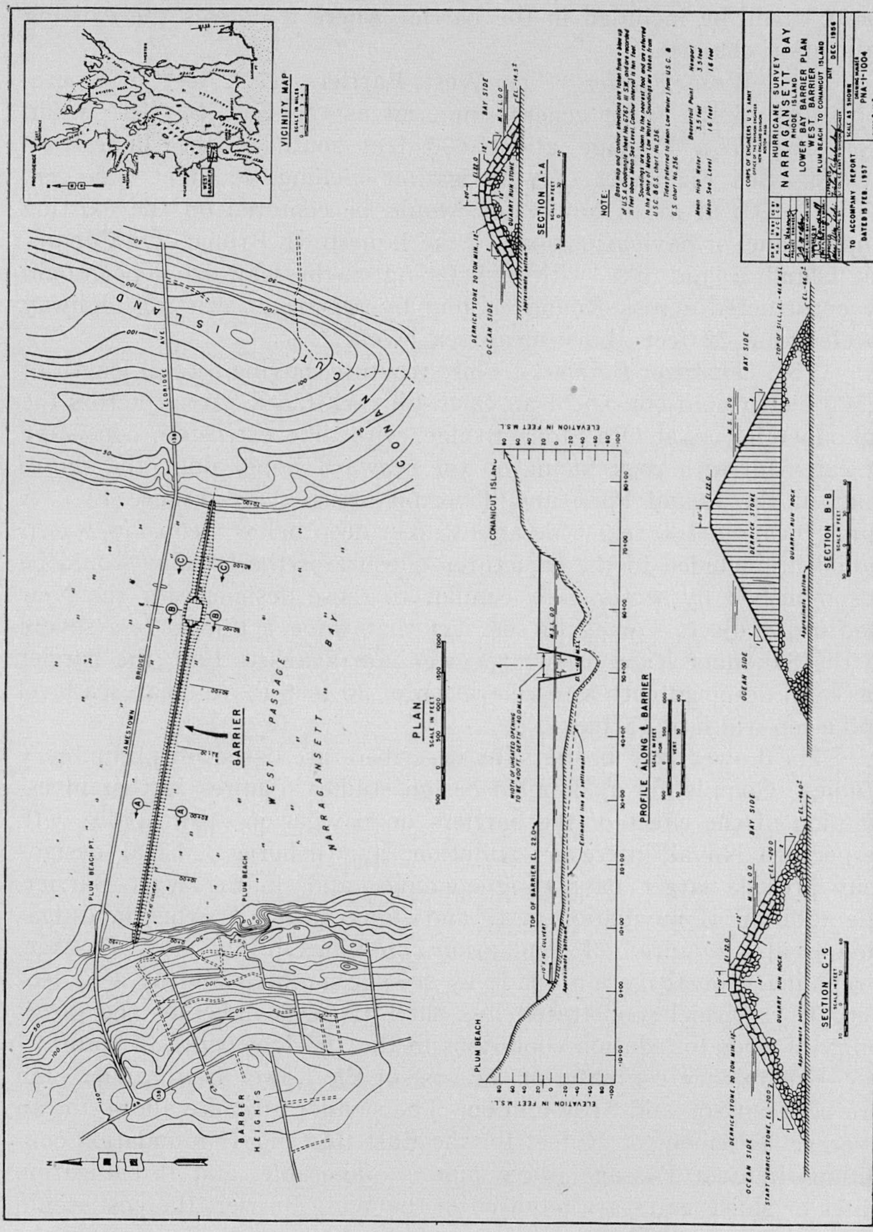


FIG. 12.—LOWER BAY BARRIER PLAN, WEST BARRIER.

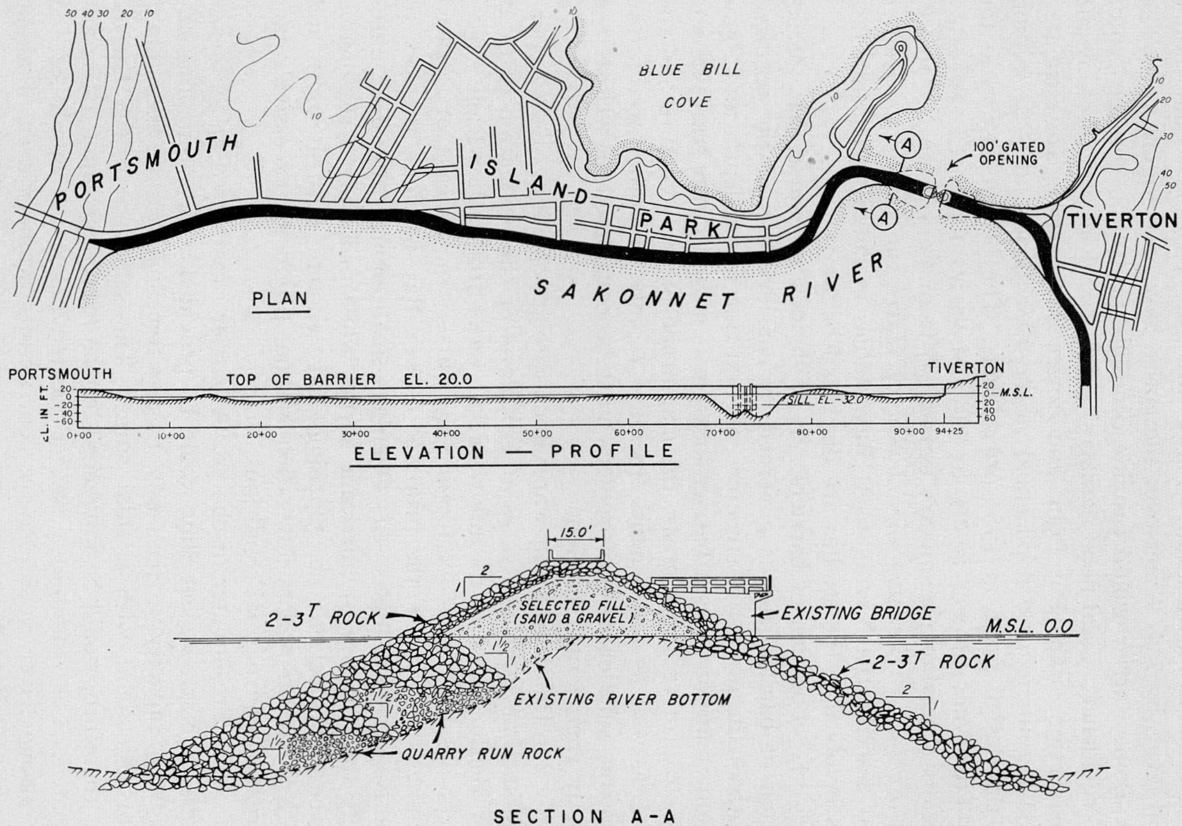


Fig. 13.—Lower Bay Barrier Plan, Tiverton Barrier.

Economic Justification. The Lower Bay barriers would reduce flood levels by 7 to 9 feet over the entire bay. (See Figure 14.) The Fox Point Barrier would provide complete protection for the center of Providence. Tidal-flood damages which would be prevented by the construction of the Fox Point and Lower Bay barriers are estimated at $120 million for a flood equal to the 1938 flood and $203 million for the design flood, at 1956 price levels. The benefit-cost ratio for the Fox Point project is 2.4 to 1.0 and varies for the Lower Bay barriers (based on preliminary estimates) from 1.6 to 1.0 to 1.0 to 1.0.

Factors Influencing the Design of Hurricane Barriers. Rather than describe the Narragansett Bay studies in detail the design factors involved in the studies are discussed below:

1. Location of barriers. It is obvious, of course that the selection of barrier sites is governed by consideration of the required length of the protective structure, the existing water depth, and foundation conditions. As a barrier location is moved down Narragansett Bay, to protect larger areas, the magnitude of the structure and the costs, as well as the benefits, increase rapidly. In other words, the economic solution of the problem must be considered as well as the strictly engineering solution.

2. Inflow of a salt-water flood through openings. Gated openings, such as the sluice gates at Fox Point or the navigation gates at New Bedford, permit no inflow of salt water from a hurricane surge, except possibly from overtopping by waves. In the case of ungated openings, such as in the proposed Lower Bay barriers, the key to effective design requires: (a) Openings small enough to restrict effectively the entrance of hurricane surges while providing a reasonable degree of protection; (b) Openings large enough, both in width and depth, to accommodate navigation without producing excessively fast currents under normal conditions.

3. Fresh-water discharge. A barrier constructed at the headwaters of Narragansett Bay would be provided with a pumping station with capacity to pass any fresh-water flood runoff that might occur coincident with a tidal surge. The selection of the barrier site, therefore, would be influenced by the maximum runoff to be anticipated. For example, a barrier located below the mouth of the Blackstone River would have a contributing drainage area of about 800 square miles. A pumping capacity of 30,000 cubic feet per second —the maximum runoff to be anticipated—precludes a barrier at this

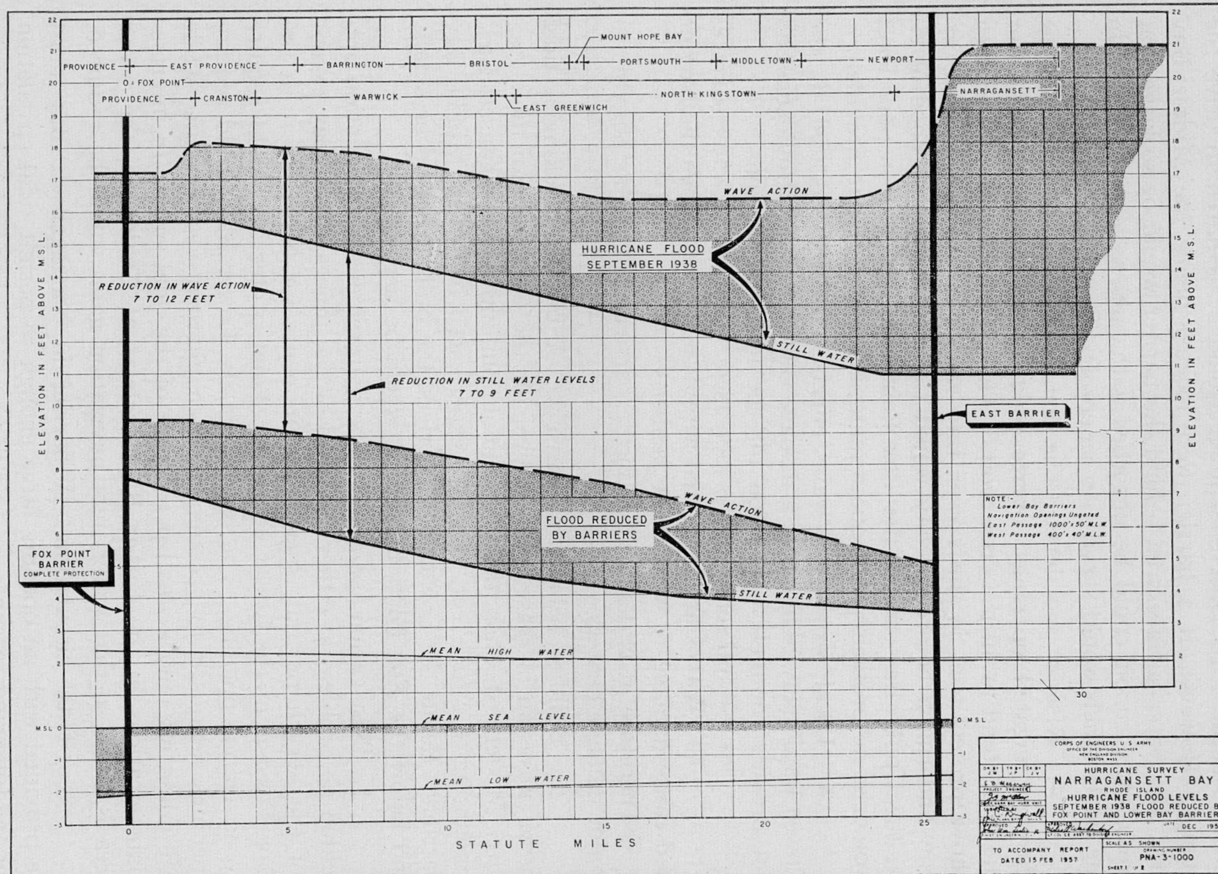


FIG. 14.—HURRICANE FLOOD LEVELS, SEPTEMBER 1938 FLOOD REDUCED BY FOX POINT AND LOWER BAY BARRIERS.

location because 100,000 horsepower would be required to drive the pumps. However, if a barrier were located below the Middle Bay area, the water-surface area behind the barrier would be so large that fresh-water runoff could be absorbed with only a very small rise in the pool, which would serve as a reservoir.

4. Rise in pool level. The combination of salt-water inflow through ungated openings, overtopping by waves and fresh-water runoff all tend to fill the "reservoir." The 120-square-mile water area above project sites in the Lower Bay would absorb considerable inflow and runoff before the bay would rise to a damaging flood level. In the Upper Bay, above the Fox Point site, the rise in pool level would be no problem if adequate pumping capacity were provided.

5. Local wind and wave effects. Barriers located in the Lower Bay, many miles from a damage center such as Providence, do not provide complete protection for the following reasons:

(a) Wind setup causes increased tilting of the water surface.

(b) Waves are generated within the "lake" above the barrier and cause damage to waterfront facilities.

Therefore, it is desirable to locate barriers as close as possible to major damage centers.

6. Buildup below the barriers. A barrier blocking a tidal surge causes an increase in flood levels on the ocean side of the structure. Model tests show that a maximum buildup in Narragansett Bay, amounting to 2 to 3 feet, would be experienced below the Middle Bay barriers. Below the Lower Bay barriers, the buildup would be small; and below the Fox Point barrier, it would be negligible.

7. Navigation openings. The requirements of navigation presented no problem at either the head or the mouth of the bay except for the very important, special requirements for Naval craft in the East Passage of the Lower Bay. Fox Point protection would require no navigation opening. The barriers in the Lower Bay would require openings adequate to accommodate commercial vessel traffic while still admitting only a small percentage of the tidal surge. In intermediate locations in the Upper Bay, such as at Conimicut, the water area is small so that water-tight navigation gates would be required.

8. Tidal circulation. A barrier in Narragansett Bay must be provided with an opening large enough to permit tidal circulation for the following reasons:

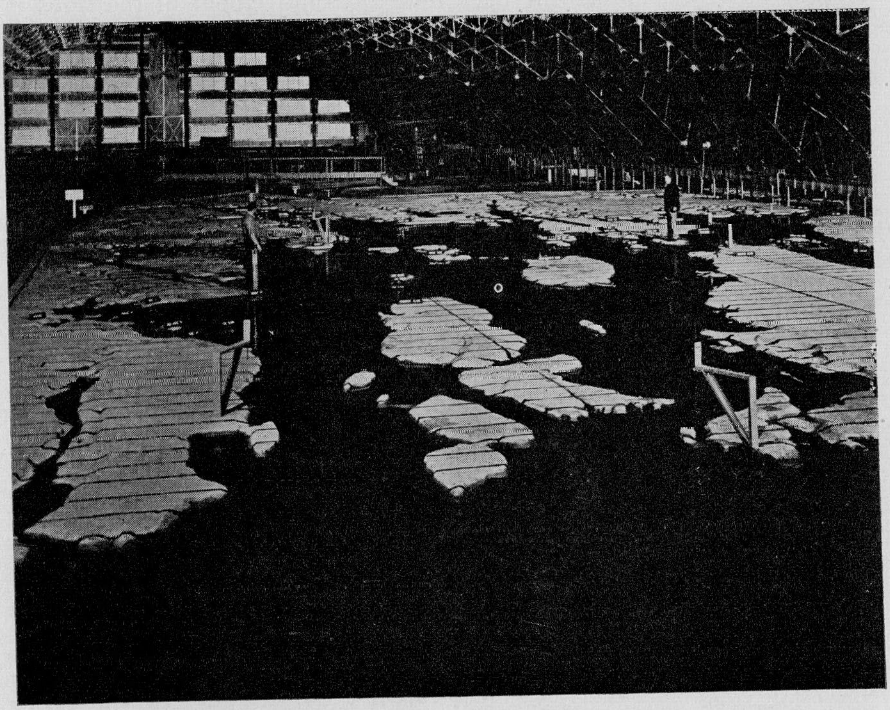
(a) To prevent damage to the $4,000,000 fishing industry in the bay;

(b) To flush the heavy concentration of industrial pollutants; and

(c) To pass the interior fresh-water drainage.

Hydraulic Model of Narragansett Bay

The complex engineering studies of hurricane protection in Narragansett Bay required a hydraulic model which was constructed at the Waterways Experiment Station of the Corps of Engineers at Vicksburg, Mississippi. The model, constructed of concrete, and housed in a steel hangar-type building, is approximately 250 feet



Hydraulic Model of Narragansett Bay Constructed at Waterways Experiment Station, Vicksburg, Mississippi. Looking North from Mouth of Bay Toward Providence. The Model Was a Valuable Tool in Studies of Tidal Conditions in Narragansett Bay and the Effectiveness of Barriers in Reducing Hurricane Flood Levels.

long and 100 feet wide. It represents the bottom of Narragansett Bay and the shoreline areas to elevation 30. The scale of the model is 1:1000 horizontal and 1:100 vertical.

The model has been used for the following purposes:

1. *To reproduce normal and astronomical tides.* This is accomplished by a pumping system controlled by different cams representing mean tide, spring tide, or the predicted tide which occurred at the time of the 1938 hurricane surge. At a large number of tide gages and measuring points, the bay and the model have been checked against each other using information from extensive hydrographic surveys. (Of course, the right information would have to be fed into the model in order to get correct answers; hence the detailed hydrographic surveys.) Since the back and forth movement of the tides in the model is almost exactly the same as in Narragansett Bay, it can be expected that the model would show the effect of barriers on normal ocean tides.

2. *To reproduce tidal surges.* This is done by a surge machine which pushes the flood surge into the model in much the same way as the wind-driven surges of 1938 and 1954 rushed into the bay. The surge machine is a 30-inch steel beam, 28 feet long, running on racks like an overhead crane. A comparison of high-water elevations in the model with those measured in the bay indicates that hurricane surges are reproduced as they occurred in Narragansett Bay. Therefore, with barriers in place, it is expected that the model would show the effect of tidal surges.

It is important to note that the model does not reproduce the local wind set-up and waves. These factors are computed analytically and added to the test results of the hydraulic model.

The first tests of the model were made using fresh water. More detailed tests are now in progress involving salinity, mixing, flushing, and sedimentation. These factors will give an indication of the effect of the barriers on currents, salinity, temperature, water quality, and pollution, and marine life in the bay.

STRUCTURES FOR OFFSHORE DRILLING

BY W. F. SWIGER*

(Presented at a meeting of the Structural Section, B.S.C.E., held on December 11, 1957.)

THE great awkward structures which have been developed for use in the Gulf of Mexico and elsewhere throughout the world in drilling for oil offshore have generated considerable interest, not only among engineers but in the public press. Together with the Macco Corporation of Los Angeles, Stone & Webster Engineering Corporation has been engaged for the past four years on behalf of a group of four oil companies, The Continental Oil Company, Union Oil Company, Shell Oil Company and Superior Oil Company, who are working together under the name of the Offshore Operating Group. During this time we analyzed and investigated a number of different types of structures, prepared preliminary designs on several structures for use in water depths exceeding 300 ft and, working with a naval architect.** have rebuilt a large hull and installed a drilling rig capable of drilling to 12,000 ft. It is not the purpose of this paper to discuss these specific installations, but rather to discuss the general requirements for the design of offshore structures, illustrating them with various types of equipment and rigs which have been used.

Any structure, be it a building, an offshore drilling rig, a flagpole or a brick outhouse, must be designed to support the equipment or materials which will be placed within it, to resist such external forces or loads as may reasonably be anticipated, to fit certain site requirements and with due recognition of the construction problems and construction facilities which will be available.

Fig. 1 shows the typical layouts of equipment for an offshore rig. This is a tripod type structure of the type planned for deep water work offshore California. This is a medium depth rig capable of drilling a 9 in. hole to about 12,000 ft. Primary power would be supplied by traction-type diesel electric units generating about 1,100 hp. Principal equipment on the lower deck consists of the power units, two large mud pumps which circulate the mud used in drilling, mud tanks, a shale shaker which separates cutting from the return

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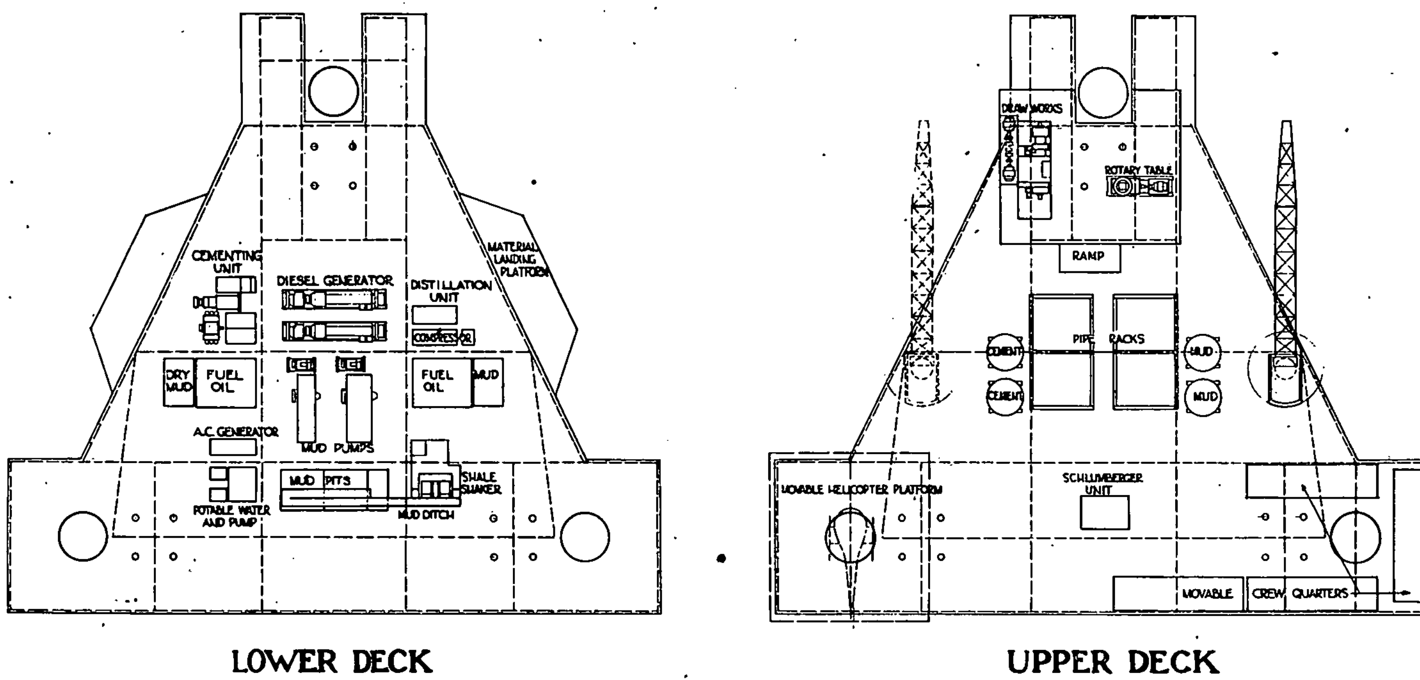

CEMENTING UNIT
DIESEL GENERATOR
DISTILLATION UNIT
COMPRESSOR
MATERIAL LANDING PLATFORM
DRY MUD
FUEL OIL
FUEL OIL
MUD
A.C. GENERATOR
MUD PUMPS
MUD PITS
SHALE SHAKER
POTABLE WATER AND PUMP
MUD DITCH
LOWER DECK
DRAW WORKS
ROTARY TABLE
RAMP
PIPE RACKS
CEMENT
CEMENT
MUD
MUD
MOVABLE HELICOPTER PLATFORM
SCHLUMBERGER UNIT
MOVABLE
CREW QUARTERS
UPPER DECK

FIG. 1.

drilling mud, some miscellaneous units, such as AC generators, air compressors, distillation unit, cementing unit and storage for fuel oil and dry mud. On the upper deck the derrick would be mounted together with the rotary table and draw-works, racks for the storage of casing and drill pipe, bins for the storage of cement, additional liquid mud and dry mud, cranes for handling materials onto the platform, a helicopter landing and quarters for the men.

The total weight of fixed equipment for this layout is about 700,000 lb. To this must be added about 2,000,000 lb. of movable supplies and equipment, such as casing, drill pipe, mud, cement, water and oil. In addition, the derrick would at times impose a heavy, concentrated load when it is handling heavy loads, such as setting casing or in the event of a stuck drill pipe. Hook loads from the derrick may range from about 200,000 lb for a light rig, to as much as 1,000,000 lb for a very heavy rig.

It will be noted that only emergency quarters for a few men are shown. Additional movable quarters of the trailer type, but mounted on skids, would be used at locations where additional crew quarters were necessary. These units can be mounted on vibration isolators which greatly reduce noise problems in the living quarters. Also, the use of separate, trailer type units affords economy over built-in quarters and greater flexibility in arrangement and future changes.

This then shows typical loads and equipment which must be supported. It must be emphasized, however, that the arrangement shown is for a medium depth rig drilling offshore of California. At other locations, much heavier equipment or much greater reserve of drilling mud might be required, which would markedly increase the loads.

External forces acting upon offshore structures include wind-waves and earthquakes. Dynamic forces from the shedding of von Karman vortex trains may cause vibration of members resonant with the vortex frequency. This must be investigated. Also, it is necessary that the over-all vibrational period of the structure be significantly less than the periods of waves which may act upon it. Wave periods off California generally range from about 5 to possibly 20 seconds for very long swells.

Wind forces are generally considered as static loads, based on a unit pressure per square foot of exposed area, in a manner similar to that commonly used for the design of towers and buildings. Consideration, of course, must be given to negative pressures on roofs, decks and on the lee side of structures. Unit pressures are generally similar to those used for land structures under similar exposure conditions and locations. Howe (1) points out that wind pressures presently used may be too low by significant amounts. During a hurricane at sea, large quantities of water in the form of rain and spray are carried with the wind. This is not vapor, which would reduce the density of the air mass, but solid particles of water. Consequently, the mass density of the fluid impinging on the structure may be significantly greater than the density of dry air, which usually is assumed in wind load analyses. This thesis is yet to be proved, but it may explain why observed wind damage under hurricane conditions is sometimes so severe.

Since the fundamental vibrational periods of the structures are shorter than the periods of design waves, wave forces may be considered as static loads for design purposes.

Determination of the magnitude and distribution of wave forces is a complex problem upon which theory and experimental data are still being developed. Early work on determining forces upon relatively small diameter structures, such as piles or caissons, was done by Morison (2) at the University of California, using 1 and 2 in. diam model piles. He found that the maximum force did not occur as the wave crest passed the pile, but at an intermediate point between trough and crest.

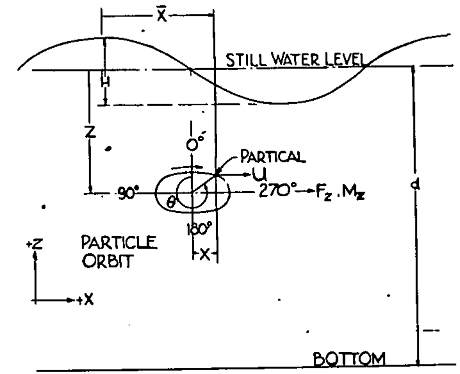
The drag on an object in steady state flow is proportional to the product of the density of the fluid, the velocity squared and a drag coefficient which is dependent upon the shape of the object. It may be shown from the theory of potential flow (3) that an object in a field of accelerated flow is acted upon by a force significantly larger than the force necessary to accelerate a volume of the fluid equal to the volume of the body. This is called the virtual mass effect. To explain the experimental data, Morison assumed both viscous drag and potential flow acceleration forces would act simultaneously. Then the drag on any unit length of such a body would be given by Eq. 1 on Fig. 2.

Assuming this expression valid, then the force exerted upon an elemental length of a body can be determined, provided the velocity and acceleration of the fluid are known. There are a number of theories for particle velocities at varying depths below the surface

WAVE FORCE ON VERTICAL CYLINDER FOR ANY UNIT LENGTH

EQ. #1

$$f_W = C_D \frac{W}{2g} U^2 D + C_M \frac{W\pi}{g\,4} D^2 \frac{dU}{dt}$$



U = HORIZONTAL PARTICAL VELOCITY AT POINT CONSIDERED

W = UNIT WEIGHT OF FLUID

g = ACCELERATION DUE TO GRAVITY

D = CYLINDER DIAMETER

C_D = COEFFICIENT OF DRAG

C_M = COEFFICIENT OF MASS

INTRODUCING PARTICLE VELOCITY AND ACCELERATION FOR AIRY WAVE THEORY

EQ. #2

$$\Delta F_W = C_D \frac{WD}{2g}\left(\frac{\pi H}{T}\,\frac{\cosh \frac{2\pi(d+z)}{L}}{\sinh \frac{2\pi d}{L}}\cos\theta\right)^2 \Delta Z + C_M \frac{W\pi D^2}{4g}\left(\frac{2\pi^2 H}{T^2}\,\frac{\cosh \frac{2\pi(d+z)}{L}}{\sinh \frac{2\pi d}{L}}\right)\sin\theta\ \Delta Z$$

H = WAVE HEIGHT

L = WAVE LENGTH

T = WAVE PERIOD

d = STILL-WATER LEVEL

Z = DEPTH BELOW STILL WATER LEVEL (NEGATIVE)

t = TIME

θ = ANGULAR PARTICLE POSITION IN ITS ORBIT

FIG. 2.

from surface waves. The oldest and simplest of these is the Airy theory, which covers waves of small amplitude only in all depth ranges, except very shallow water. The Stokes theory, which properly is limited to medium height to low waves in deep water, more closely approximates the actual wave form and particle motion, but involves more difficult mathematics. The Mitchell theory applies to maximum height waves in deep water. As waves enter shallow water and approach the breaking point, they assume a sharp, peaked trochoidal form which closely approximates the wave form and velocity distributions of the Solitary Wave Theory.

No one theory presently available gives particle orbital velocities or accelerations in the shallow to intermediate water depths for the steep, maximum waves encountered under design. storm conditions. The Solitary Wave Theory, which applies reasonably well to high, steep waves near breaking in shallow water, is most commonly used in the analysis of structures in the Gulf of Mexico. Reid and Bretschneider (4) have used the Stokes, Mitchell and Solitary Wave Theories as limiting conditions, extrapolating them by means of certain dimensionless parameters to cover intermediate conditions.

By combining Eq. 1 with the expressions for horizontal particle velocity and acceleration for the Airy Wave Theory, Morison obtained the expression Eq. 2, Fig. 2, for the drag in still water on a vertical pile or structure of relatively small diameter as compared with the wave length. It will be noted the drag term and the acceleration term are 90 deg out of phase. If there are no currents, this may be integrated through the depth of water to obtain the total drag acting. Also, by integrating the product of the drag for each elemental length and its arm above the bottom, the moment may be determined. If there are significant currents, the velocity distribution must be established and the velocities from waves and currents added vectorially. Total shears and moments can then be determined by integrating by finite increments. This must be done for several different positions of the wave with reference to the structure, i.e. for several values of θ, to determine the maximum force acting on the structure.

By measuring the drag at the crest and again at still water level, Morison evaluated the coefficients of this expression, assuming these to remain constant through the wave cycle. These early studies gave approximate values of $^{c}M = 2$ and $^{c}D = 1.5$, based on the small diameter model pile tested at Reynolds Numbers reaching maximum values of about 3,000. There was considerable scatter in the results. Reynolds Numbers for the major elements of actual structures are in the millions.

Despite a number of theoretical objections, this remains the most commonly used expression for determining wave forces. Many studies are under way to refine the theory. Model tests are under way at several research centers, large-scale experiments are under way along the Gulf Coast and several have been completed off California.

On the Gulf Coast, the most commonly used values seem to be $^{C}D = 0.5$ and $^{C}M = 1.5$, although values of ^{C}D ranging from 0.3 to 1.5 and values of ^{C}M varying from 1.2 to 1.7 have been used by various designers.

The Drag Coefficient, ^{C}D, is not a constant, but varies with Reynolds Number. Further, there is reason to question whether the Acceleration Coefficient, ^{C}M, is constant throughout the wave cycle. Recent studies by McKown and Kuelegan (5) at the University of Kansas and by Harleman and Shapiro (6) of M.I.T. have shown that these coefficients are far from constant and may be interrelated. Despite its limitations, however, it appears from the experience on the Gulf Coast with recent hurricanes that this basic expression with coefficients $^{C}D = 0.5$ and $^{C}M = 1.5$ but revised for the velocity distributions of the Solitary Waves gives reasonably safe results for shallow water, at least if used with an adequate factor of safety.

Crooke (7) has taken a different approach to the problem. It may be shown by Dimensional Analysis that for accelerated flow, in addition to Froudes Number and Reynolds Number, there is a third dimensionless parameter which must be satisfied. He has related the total drag on a cylinder to this dimensionless parameter, $\frac{aD}{U^2}$ which is called the Acceleration Modulus, the drag being given as $\Delta F = C \frac{w}{2g} \cdot U^2 D \Delta L$. Plotting data from a number of tests seem to indicate a family of curves approaching values of "C" ranging from 0.5 to 1.2 for various Reynolds Numbers at low values for the Acceleration Modulus. The curves converge for higher values of the Acceleration Modulus.

As can be seen from the above, knowledge of wave forces is in a state of development. Before entering into design of structures in which these are involved, it would be well to review thoroughly the literature and to gain an understanding of the limitations and possible inaccuracies of the several theories presently in use.

Determination of the maximum or design wave height poses further uncertainty. On the flat bottoms, the maximum height at which a solitary wave begins to crest is $H/B = 0.78$ where H equals the wave height, trough to crest, and B is the distance from the trough to the bottom in feet. In shallow water, the maximum wave height will be determined by the breaker height. In deeper water, usual practice is to make an analysis of wave height based upon the maximum storms anticipated. Theories for determining wave heights from storm conditions, either from observed winds or from synoptic weather charts, have been developed, for example, Sverdrup and Munk (8) or Neumann (9).

Work by Sverdrup and Munk was done during the war to predict surf conditions for beach landings. It gives the significant wave height; that is, the height exceeded by one-third of the waves. This is generally satisfactory for indicating the state of the sea as it affects military operations. The relative height of the maximum wave for design purposes to this significant wave height, however, is not yet clearly defined. Present data indicate it probably lies between 1.25 and 1.5. Design waves of 45 to 50 ft in height have been commonly used in the Gulf Coast area for deeper water locations. Offshore California, we have used a design wave of 30 ft.

The low barometric pressure near centers of major storms and the drag of the wind on the water surface result in a rise in surface water levels, especially in shallow water such as the Gulf of Mexico. This storm tide may amount to 15 ft or more and must be considered, both in evaluating the maximum breaker height to be expected and in establishing the elevation of the floor or platform of the structure, in order that it will be above the highest waves during storms.

Nationwide exploratory drilling has averaged about one producer for nine dry holes over many years. The record offshore is much better than this, but even there about 60% of the holes have been dry. This fact, together with the high cost of doing work at sea, has led to the development of a number of specialized drilling rigs which can be moved from place to place as each well is drilled. These movable rigs are so arranged that after the well is drilled, a small light production platform can be installed, if it proves a producer, and the rig itself moved to another location. Moving time on some of these rigs is surprisingly short. Some of them can move from one location to another in less than a day. Thus, there are now working offshore in the Gulf two broad general types of rigs; fixed rigs, that is rigid structures usually designed for a specific site, and movable rigs adaptable to a wide variety of conditions.

Rigid platforms are usually constructed following the principles shown on Fig. 3. A braced template, or jacket, is set upon the bottom. The top of this jacket extends to just above water level. The vertical members are hollow pipes of sufficient diameter to pass the piles which will be used. This jacket is set by a large capacity, barge-mounted crane. After it is in position, piles are driven through it and cut off at proper level. A platform or deck structure is then erected upon the piles and the machinery mounted upon it. To minimize construction time at sea, extraordinarily heavy equipment and barge cranes are used which can handle and set large, prefabricated units. Several cranes are available having a lift capacity of 250 tons and one with a lifting capacity of 800 tons is now in service in the Gulf Coast area. The deck sections are usually prefabricated and the drilling equipment skid-mounted in preassembled units which can be set in a minimum of time and with a minimum amount of labor.

Structures of this type have been used to water depths in excess of 100 ft. Common practice is to drill two or more wells from each structure. Rigid structures may be self-contained, that is, all necessary facilities, supplies and equipment may be carried upon the structure or a platform for the support of the derrick and draw-works only may be erected and a tender anchored alongside on which are carried the mud pumps, generating units, pipe racks, casing, living quarters and the other supplies necessary for drilling the well.

Of the movable rigs, the most common is a submersible barge or some version of it. The simplest and earliest of these, shown at A in Fig. 4, is simply a barge having a sufficient depth of hull that it can be towed to the selected location, flooded until it rests on the bottom, and then the well drilled. When the well has been completed, a protective structure, usually a simple pipe caisson 4 to 6 ft in diam, is set around it. The barge is then refloated and towed to another

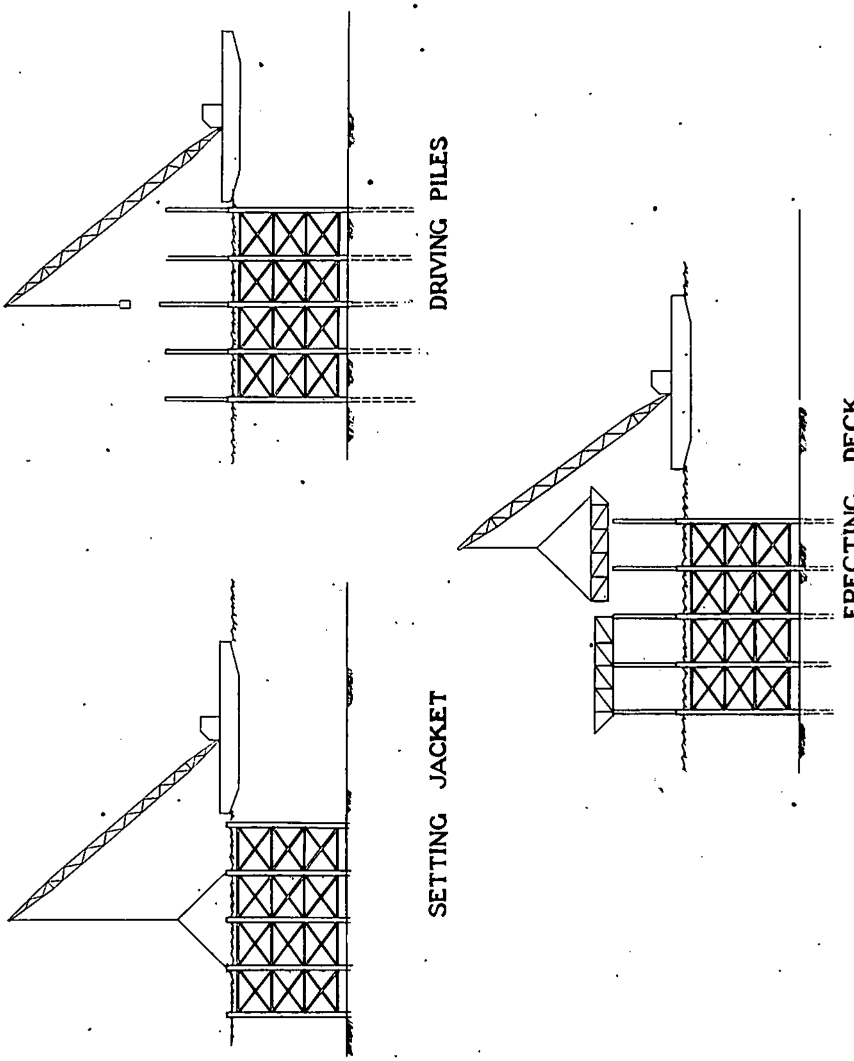


Fig. 3.

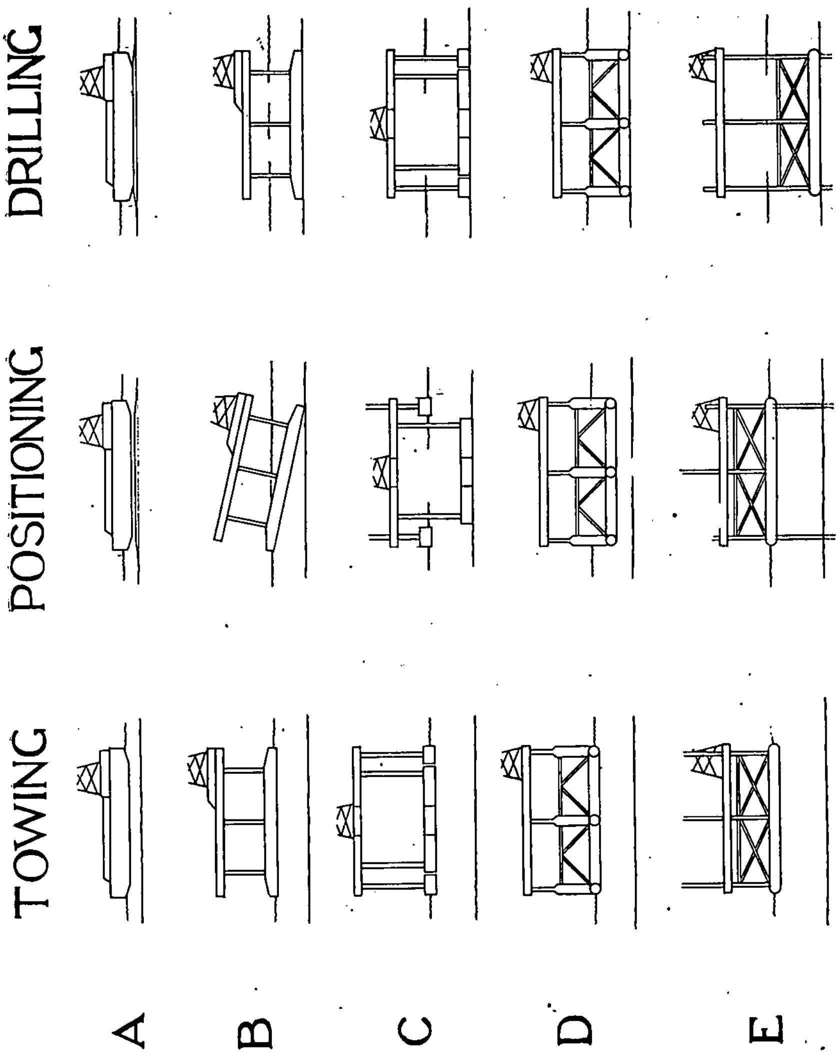


FIG. 4.

location. Units of this type can be used only in shallow water which are protected by offshore bars or by permanent or temporary breakwaters, since the freeboard is small when in the drilling position and even low waves would wash over the deck.

To prepare a site for using one of these types of structures, the ocean floor is leveled, if necessary, and usually a layer of shells 2 to 5 ft in thickness is placed on which to set the barge in order to prevent excessive suction forces when moving off location. These barges were first developed for drilling in bayous and other inland waters along the Texas and Louisiana Gulf Coasts. They were first placed in service in the late thirties and have probably drilled, by far, the greatest number of wells located over submerged lands.

For exposed locations which will not be protected by breakwaters against wave action, it is necessary that the working deck be located about 40 ft above water level. Otherwise storm waves will strike the deck. Several types of barges have been developed in which the working deck or platform is supported well above the top of the flotation barge. Various techniques are used to stabilize this type of structure while sinking the flotation barge to the bottom. This is necessary because once the flotation barge sinks below the surface, there is no longer a righting movement to prevent capsizing unless special precautions are taken. Some of the techniques, which are used to maintain stability while placing the barge, are shown on Fig. 4. For the unit shown at B, one end is sunk to the bottom while the other end remains above water level, the floating end maintaining stability until the sunken end is on the bottom. The end on the bottom then prevents capsizing until the other end can be sunk to the bottom. In another type, shown at C, outriggers are used to provide stability until the main flotation barge is safely on the bottom. These are then lowered to provide additional support during the drilling operation.

A structure which was placed in service during the past year is a logical outgrowth of the simple submersible barge first discussed. In this structure, shown at D, the main flotation members consist of a grid of large diameter cylinders. Extending upward from these cylinders are vertical, large diameter cylinders. The structure is positioned by flooding the lower members until it sinks to the bottom. Lateral stability is provided by the vertical cylinders which are not flooded until after the unit is on the bottom. This simple, direct concept has much to recommend it.

The types of barges discussed above are usable only in shallow to moderate water, that is, to depths of about 50 or 60 ft. To permit operations in deeper water up to a maximum of about 100 ft, Mr. Gus I and Mr. Gus II employ the technique illustrated at E. When in position over the site, four or more large diameter caissons or piles are forced into the bottom, one at a time, by a jacking system. The upper hull is then clamped to these piles and the lower hull flooded and permitted to slide down the piles until it reaches a position on the bottom. The lower hull is then clamped to the piles and aids in stabilizing the entire structure against wind and wave forces.

Mr. Gus I capsized this past spring when coming off location on a dry hole. The piles along one side settled, tilting the rig. During attempted righting operations, a heavy crane barge was driven into the rig by a rising sea. When the dust cleared away, Mr. Gus had completely capsized. The rig was cut apart and the individual portions removed in salvage operations. Presumably, it will be rebuilt and placed back in service or the components used in a new rig.

Elevating barge structures employ a different concept. In this type of unit the operating platform is built as a barge hull, which is floated into position. The legs are then lowered to the bottom and one by one are forced into the bottom by a jacking system until they are capable of taking load. The legs having been positioned, the barge is then raised by the same jacking system until it is in proper position above the ocean. Three or more legs may be used. The individual legs may be caissons or piles of 4 to 6 ft in diameter, which are forced into the bottom to afford the necessary support, or framed structures with large diameter spread footings.

A number of different jacking devices have been used for lowering the legs and forcing them into the bottom and then for hoisting the platform to position. Usually, these employ much the same technique as a small boy shinnying up an apple tree. Basically, they consist of an upper and lower clamping device, together with a hydraulic jack system. The barge is usually attached and supported at the lower clamping device. By alternately clamping the lower and then the upper device while raising the other by means of the hydraulic jack system, the barge can be lifted in increments of from 6 to 48 in., depending upon the equipment used. The clamping devices may depend upon friction as in the Delong hydraulic jacking system used on the first Texas Tower erected off New England and in the

Roebling wire jacks used on the last two Texas Towers, or positive support may be provided by a system of pins entering slots or holes in the legs.

Elevating deck platforms designed and constructed by R. G. LeTourneau, Inc. employ a different type of hoisting device. On these units a rack and pinion arrangement is used. The rack is fixed to the legs of the unit. The pinion gears, which engage the racks, are supported from the platform and are driven individually through geared-down electric motors. These motors operate on direct current and are so wound and controlled electrically as to share equally in the lifting load.

The structures described above are well adapted to operations off the Gulf Coast. Here the bottom is very flat, sloping only a few feet per mile. Thus, offshore structures located as much as 40 to 50 miles offshore may be in only 80 to 100 ft of water. Off the coast of Louisiana, the bottoms generally consist of very soft clays. Off the coast of Texas are many areas where the bottom is of hard-packed sand. Both clay and sand bottoms are reasonably level and free from depressions or humps which would make positioning of a large, flat-bottomed structure difficult. Thus, both the pile type structures and the barge type structure, in which a large, flat base is set upon the ocean bottom at a very low bearing value, are well adapted to foundation conditions. With the flat base type structure, it is, of course, necessary to protect against scour from wave or current.

Conditions off the California coast are quite different. While the area is not subjected to the severe hurricanes and the accompanying extreme high waves of the Gulf Coast, foundation conditions are variable and water depths may be extreme. The general slope of the bottom off California is much steeper than off the Gulf Coast and there are a number of submarine canyons and other depressions. Consequently, water depths in excess of 250 ft may be found within a few miles of the shore and the 100 ft contour is close inshore, generally only about 6,000 ft off the high tide line. Topography of the bottom is rough and slopes approaching 10 per cent may be found at many locations, while along the sides of the submarine canyons slopes exceeding 20 deg may be found. Bottoms vary from soft clays to compact sands to shale or sandstone and in one area a hard limestone is found.

Portable structures for use offshore of California must be adaptable to a wide range of water depths, including extreme depths, to a wide range of foundation conditions and to sloping sites. Further, because of the character of the formations in which the oil is found, more extensive exploratory drilling, both to locate the oil and to establish the geology of the oil fields and the reserves in each pool, is necessary than is the case off the Gulf Coast.

Until 1955, production or drilling for oil off California was limited by law to areas contiguous to onshore production and then only from land filled to above high tide level. Except for some old pile supported piers erected before controls were adopted and which extend only a short distance out to sea, the first two ventures offshore of California are filled land structures. The first of these is a circular sheet pile caisson filled with rock. The second is an island of dredged fill protected from waves by a heavy rock breakwater.

Following rescinding of these laws in 1955, several leases were put up for bid. Other larger leases were recalled from bidding during February 1957 at the request of the State Legislature who reconsidered and modified the leasing laws. It will probably be early 1958 before new bids will be taken on leases under these modified laws. As yet the Federal Government, which controls leases between the continental shelf and the 3 mile limit, has not taken bids for leases in these waters. Consequently, development of offshore drilling off California has been slow and its future is not certain. One elevating platform barge of the Delong type was purchased in the Gulf of Mexico and brought through the Panama Canal. Jacketed pile type structures have been considered for the shallow water locations and we and several other organizations have developed designs which are believed capable of operating in waters several hundred feet in depth. To our knowledge, however, as yet none of these deep water structures have been carried past the preliminary design stage.

We propose to use a three-legged structure consisting of a base section and a platform which will be hoisted to position after the base is set. The base section would be constructed lying on its side. It would consist of three 12 ft diameter caissons arranged in the form of an equilateral triangle 125 feet on a side with suitable bracing between them. It would be floated to position and then tilted to the vertical by controlled flooding of compartments in the 12 ft diameter members. After it had been seated upon the bottom, it would be supported either by piles driven through pile wells or by a system of footings sunk into the bottom, depending upon bottom conditions. The platform with drilling equipment mounted would then be floated into position and hoisted to its operating position.

This is the same technique that was used in erecting the third Texas Tower off this coast in 180 ft of water in July 1957. The basic design of the structure is complete and details and methods of supporting it on sloping bottoms with a wide variety of foundation conditions have been developed. Basically, these contemplate the use of various types of footings or piles which can be installed after foundation conditions at a specific site have been determined and changed for use at a different site.

Exploratory drilling is particularly important off California. The most obvious solution is to use floating equipment, that is, to drill from a barge, but this is not quite as simple as it may seem. For best drilling efficiency, the portion of the weight of the drill string kept on the bit must be closely controlled. In drilling with rotary equipment, mud is forced down through the drill string and back up around the string to the surface, carrying with it the cuttings. Drilling mud is an expensive item, viscosity, density and jelling characteristics of which are closely controlled during drilling. It must be recovered and reused, both because of expense and to avoid contamination of the ocean.

In addition to removing cuttings, mud serves the very important purpose of counterbalancing gas pressures which may be encountered in oil or gas bearing formations. In the event gas pressures in excess of the bottom hole pressures of the mud column are encountered, the mud will become filled with gas bubbles. Presence of the gas bubbles reduces the weight or pressure of the mud column further, permitting more gas to enter it. Thus, a dynamically unstable condition develops and the entire mass of the mud may be shot violently out of the well in a gusher. Such a gusher may result in destruction of the rig and, if the gas catches fire or the well craters, loss of the well. At sea the hazard is even greater and a blowout might result in considerable loss of life. To prevent gushers, blowout preventers are installed. These are large valves which close around the drill stem or across the casing in the event a blowout seems imminent. Gas pressures at the wellhead of 3,000 to 6,000 psi are common and one well in the Gulf recently had pressure exceeding 10,000 psi. The loads on these blowout preventers are large. To withstand these loads, they are bolted to casing strings which are cemented deeply into the earth.

As the well is drilled, it is necessary to change bits at intervals, usually about once a day. Further, several strings of casing must be

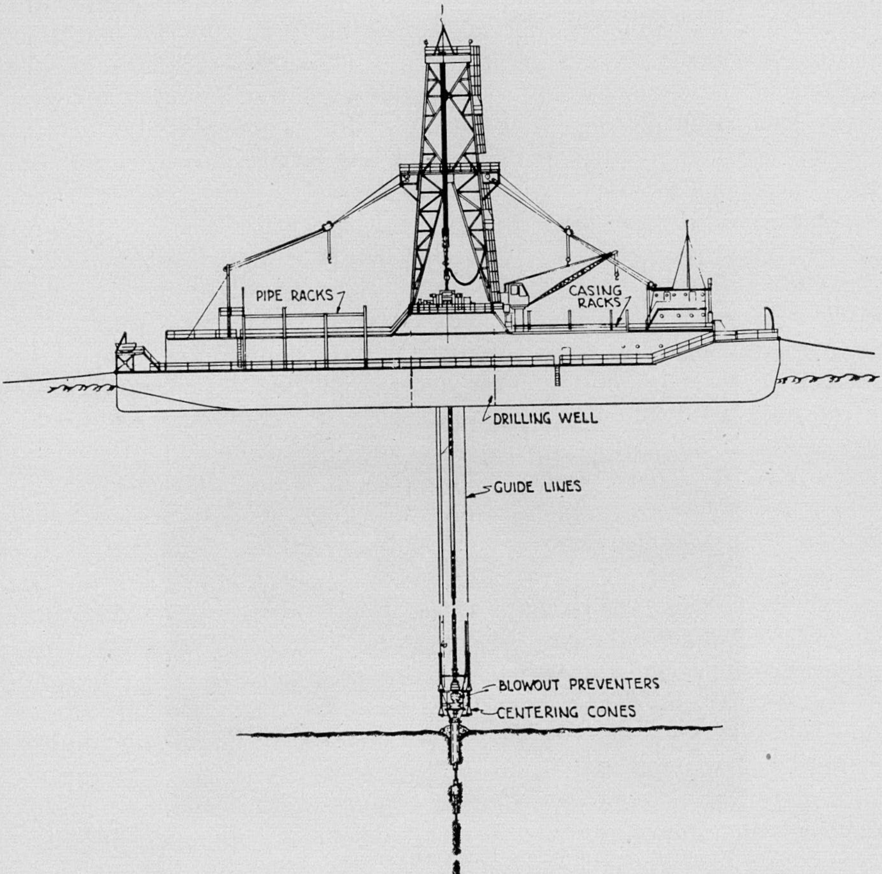


FIG. 5.

hung in the hole and then cemented into position. By using a special wellhead structure with the blowout preventers set at the ocean floor and with mud return lines from a special connection above the blowout preventers, together with guide lines and cone type centering devices to permit entering the hole with the drill string or casing, these problems have been met and drilling is presently being done with barge mounted equipment. A surplus Navy barge, 260 ft long by 48 ft beam, was modified and drilling equipment installed, together with necessary specialized equipment for this type operation.

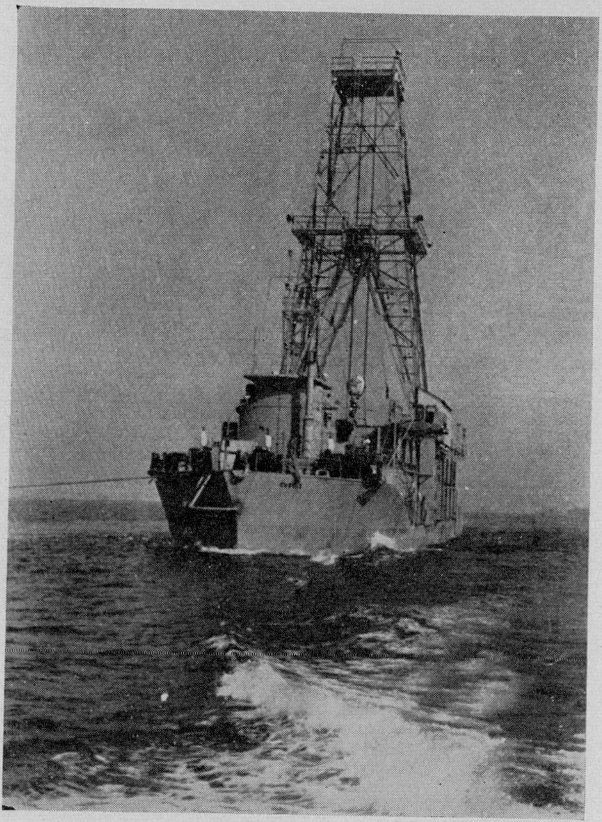


FIG. 6.—BARGE OFFSHORE.

The equipment is so designed that the barge can leave the site and return to it at a later date and resume drilling. Fig. 5 shows the general arrangement of this barge and the underwater gear. Fig. 6 shows it offshore of Long Beach. Fig. 7 shows details of the bent used to support the derrick structure in order to distribute its concentrated loads over the middle portion of the barge and thus reduce bending

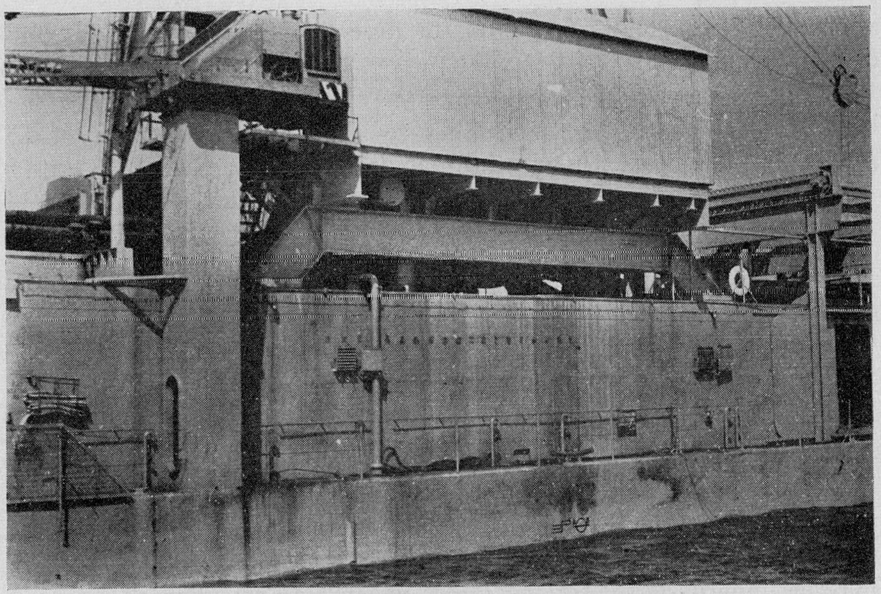


FIG. 7.—STRUCTURE SUPPORTING DRILLING DECK.

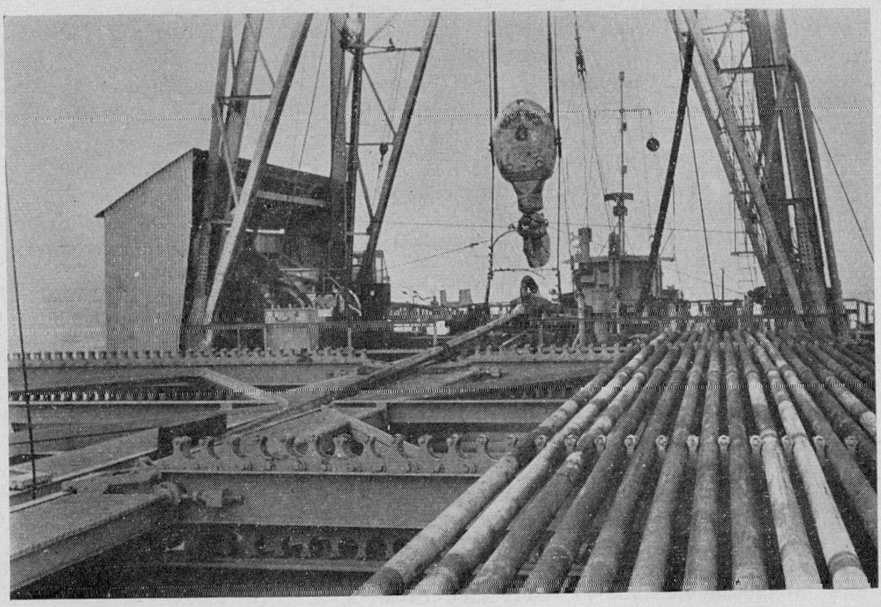


FIG. 8.—DRILLING DECK WITH PIPE RACKS IN FOREGROUND AND DRAW WORKS IN LEFT BACKGROUND.

moment. Fig. 8 shows details of the pipe racks, the draw works and the traveling blocks.

This barge has drilled in water depths from 50 ft to more than 1,500 ft. It is capable of drilling to a maximum depth of about 12,000 ft. The deepest to which it has drilled to date is about 6,300 ft. It has averaged about 450 ft of hole per day during its service and the unit has drilled as much as 1,100 ft in less than 8 hr.

Development of this barge and of the other structures described was in close cooperation with personnel of the Offshore Operating Group. This group of oil companies holds the basic patents on the specialized equipment developed.

This is a rapidly changing field. Possibly this brief summary will give some insight into the problems which are faced in designing these intensely interesting structures. It is hoped that in the reasonably near future more accurate information will become available on wave forces and probable maximum waves. At the present time, there is reason to believe that many structures are overdesigned, yet others may be underdesigned for the forces which may act upon them.

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SOME CONSIDERATIONS OF THE PAST AND THE FUTURE OF REINFORCED CONCRETE

By Dr. Giulio Pizetti*

(Presented at a meeting of the Boston Society of Civil Engineers, held on December 18, 1957.)

More than a hundred years have elapsed since the birth of reinforced concrete and I think it would be interesting to review its developments, try to define its functional characteristics and to study its modern and future trends.

In order to accomplish this—stressing the structural point of view rather than the architectural—let us first give consideration to structures and the basic structural trends of men.

Generally speaking we may define a "structure" as a grouping of static channels used by men in order to convey to the ground, forces which have to act in a certain position in space. The position and magnitude of these forces are the data of some architectural problems and therefore we can say that the structure does not exist for itself but only as a part—as important as it may be—of a more complex unit.

This hypothesis raises the question of relationship between architectural composition and structure, but I do not intend to discuss this phase of the problem. I wish only to recall that the structural problem, i.e. the determination of the most appropriate static channels has been solved by men in two basic ways. Let us consider, in fact, that static channels are supposed to carry two passengers—"the force" and "the moment of the force". We shall then find it logical that men—first by intuition and then in a rational way—tried to build static channels according to the exigencies of those two passengers. From this attempt two basic structural trends have arisen: the first intended to serve mainly "the force", the second to serve mainly "the moment".

The first trend is the most elementary and the most logical to the intuitive mind: get rid of the moment, take only the force, the compression or tension which is so simple, so visual, so prehistoric. It is the trend of the architecture of latticed structures, the modern trend

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of shell structures and of hung roofs. We can take as its symbol the curved line and observe that, in general, this structural trend is the most economical as far as the material is concerned, but more expensive as to labor.

The other trend, the one which decides to serve the moment as principal passenger, is the trend of the straight line and the combination of straight lines. It leads to the beam, the frames, the plates. We may state that this trend is less economical as far as the material is concerned but more economical as to labor.

Those are the two basic structural trends and therefore structures, although in general conforming to both of them, can be related to one more than to the other. Some architects accept only the straight line as static channels, while others prefer the curved line trend, but in the over-all perspective we can have no preference. The important thing is to observe that these two trends are something fundamental in the economy of the universe, have defined every structure of the past and will define every structure in the future. Many things in the world may be changed by the nuclear era, but statics adhere so closely to the fundamental laws of mechanics as to rule any future of the structural world.

On the basis of these preliminary considerations let us take a look at the evolution of reinforced concrete. At the birth of this new material, its manifold possibilities and its superiority to steel in its adaptability to molding new forms were realized in some prophetic way by the architect and the poet. "Neither economically nor structurally"—said Rabut—"is there any risk we dare not take. At long last architecture has escaped from its cubic prison cell" and again Paul Claustel "Architects should mold reinforced concrete with their fingers as the hatter shapes the felt of a hat. Reinforced concrete is no rigid material but an adaptable tissue, a heavy felt . . . to be stamped by a single blow of the imagination". Words of a poet, not of an engineer, but not crazy words; a flash of intuition, a prophetic vision of a big field of possibilities.

In fact it is worth while to observe that reinforced concrete at the beginning was conceived as a material for structures that are form resisting rather than mass-resisting and many of the early patents in the field of reinforced concrete treat of the new material rather from the point of view of the form than of the mass (Cambot's boat, tanks, small domes). But in the second stage, and mostly after dependable theories of calculations were achieved, reinforced concrete took its inspiration from the architecture of steel, wood and stone. Its fundamental characteristic, that is, being a cast stone with infinite possibilities of monolithism, is lost in a series of common static schemes: from slab to secondary beam, from secondary beam to principal beam, from principal beam to column. In other terms reinforced concrete is mainly exploited as a static channel in the plane, as a kind of substitute for steel in countries in which steel is expensive, but its possibilities of expressing new forms in space are scarcely taken into account. Before World War II there were few examples of reinforced concrete structures conceived as resisting by form as a spacial whole, and not as a mere repetition of plane elements, and only now, ten years after the end of the 2nd World War can we say that reinforced concrete has also taken that orientation which fits its possibilities so well.

As a matter of fact, with the perspective of a hundred years we can say that reinforced concrete is the material having the greatest possibilities of expression both for the architect and the engineer. It is able to express the "moment's trend" used as static combinations of straight lines and plates; it may be unique in the expression of mass resistance as in dams, foundations, etc., and may be considered architecturally as the material of the future if we learn properly to exploit it in the field of double curved structures in space.

As a material for structures in the plane, reinforced concrete shows very clearly its limited possibilities. According to the French engineer Lossier the limit of the straight line, as expressed in a Gerber beam (we are speaking, of course, of economic limits) is up to 1500 feet; for the curved line as expressed in the arch, up to 2100 feet. Yes, we are still far from these figures, as figures, but the structural forms are quite well defined and we can say we have enough experience to be able to face such problems when the time comes. If you wish we can say also that improvements in the quality of materials, stronger concretes and high tensile fibers will lift the actual ceiling: but the structural forms will not change.

On the contrary, as far as curved structures in space are concerned we can state that we are only at the very beginning and have not yet perceived the full panorama of the importance and significance of future achievements. As a matter of fact the curve as a static channel, when it becomes a curved surface with infinite nets of static possibilities, is more logical in reinforced concrete than in steel. Why then has reinforced concrete been used so little in this direction, in its own realm, and used so widely as a mere substitute for steel in fields which properly belong to the latter? The reasons are fundamentally three.

(1) The difficulty of calculation and design of spacially curved structures.

(2) The high cost of construction, if we use the usual methods of scaffolding and formwork.

(3) And last but not least, concealed behind the first two, but nevertheless visible, the mentality of routine, the fear of new experiences, and of risks in exploration of new worlds. We are too busy with the ordinary constructions; we have to meet so many necessities of men in the most common fields, that no time nor lust is left for poetry and new forms.

This point of view, which is quite comprehensible, is in a certain way related to and responsible for the slow progress in the field of structural engineering. Since structural engineering adheres closely to the first principles of statics, this is the primary cause of the slowness of its pace. But this same slowness contributes to a growing complacency, to a mentality of established routine, and reaction to new approaches to problems, all of which are quite difficult to change. Better to say that this mentality is difficult to attack directly on the basis of more or less transcendant principles: far better is the indirect fight—trying to reduce to their true proportions the other two obstacles previously mentioned.

1. *The Difficulties of Calculation and Design.* They are quite true and actual, especially in comparison to the kind of difficulty we meet in standard designing. But they can be overcome if we properly coordinate our powers of analysis. First the school must be able to give back both to the architect and the structural engineer the same static sensibility, lifting their intuition to the level of our times, raising the platform of their conception, and giving the proper importance, no less but no more, to the mathematical weapon. After this work the school and profession must get the right orchestration between architect, structural engineer and mathematician who are now going their separate ways, eventually finding the best way to exploit the tremendous possibilities of calculating machines.

Let us recall for instance the story of calculations of cylindrical shells. Up until 1935 they constituted a sort of transcendental mystery only divested by the German school and utilized for practical purposes by the firms of Dyckerhoff and Widmann. Now I do not dare say that cylindrical shells are beyond the reach of every engineer but we can say that they are ready to be completely tamed by properly using elastic coefficients, by widely utilizing the ultimate strength design, but above all, with an appropriate teamwork and an intelligent use of digital computers.

But if we consider double bent surfaces instead of simple bent ones we see that we are today, with the exception of surfaces of revolution, at the same stage as were cylindrical shells 20 years ago. It is not therefore Utopian to think that the analytical rock can be surmounted if we convince ourselves that we have enough good reasons to do it. It remains therefore as a fundamental and most difficult obstacle.

2. *The Economic Side of the Problem.* On this subject we have said that in general spacially bent structures allow saving in material but are expensive as far as labor is concerned. In the case of simply curved structures, like cylindrical shells, the negative aspect of the question is not so bad, but for double curved structures generally it makes itself strongly felt, in such a way as to overcome the saving in material. Therefore in the world economy of today we have outstanding examples of double bent shells mostly in countries in which labor is comparatively cheap and the saving in material is the capital aim such as Italy, Spain, and Mexico. The United States, although having an average income which is five times that of Italy and about ten times that of Spain cannot afford, it seems, the construction of shells unless they can be achieved in a program of scale production. I think that on this subject more remarks of a general nature can be made. I do not pretend to be an economist, but I think that we should approach the problem with a broadness of mind in keeping with the events of our century. Evidently the fundamental laws of human economy will not change unless man himself changes, but the economic divisions in the world, the economic intercourse between nations is most likely to change, and rather quickly, in the near future. The world is becoming very small—everybody realizes it—and it will become even smaller in the immediate future. In Italy, to give a little example, many changes are to be anticipated with the coming of the European common market. We realize that in the years

ahead we cannot pretend to stand the competition of steel in every field of construction. We must withdraw reinforced concrete from those applications in which it is not a logical solution but strengthen it in those fields in which it properly belongs. I do not pretend that the economic situation of today between Italy, France and West Germany will repeat itself tomorrow between Europe and America but we can predict, without pretending to be prophets, that the future will tend to eliminate or at least reduce the difference in the shape of the economy of different countries. In other words, as far as reinforced concrete is concerned it is evident that its future will, economically, be more in the field of space structures than of plane ones. How many years this economic evolution will take, I do not know. Probably it will affect the generations of our sons rather than ours, but we have to expect it and prepare ourselves for it.

If we adopt this line of thinking we shall then realize that there exist several interesting methods worth studying and developing in order to solve the economic problem. Let us look first at the efforts of Nervi. I do not intend to touch on the architectural phase, but only on the technical. Nervi's wonderful achievements can remain in competition with other types of common structures, thanks to the clever use of "ferrocements".

Ferrocement is a kind of reinforced concrete in which the percentage of reinforcing is higher than in the usual structures and is constituted mostly of meshes of thin wires, uniformly distributed throughout its thickness (which is generally very small). It is a material of strong homogeneity able to resist both tensile and compressive stresses, and able to sustain pouring without the help of formworks, due to the stability of the shape of reinforcing, when it is properly curved.

On the basis of this idea Nervi has developed several combinations of ferrocement and common reinforced concrete by using ferrocement as a mold for repeated units or as a first layer for more complex structures.

It is a method which is worth being thoroughly studied, because it is still in the development stage and could be brought to a broader and better stage through systematic tests in laboratories and in buildings.

Another interesting path is the clever combination of precasting and prestressing. Everybody knows the reasons for the birth of precasting, a technique which is not at all a modern discovery since the first precast units were born more than 60 years ago. They are fundamentally related to the solution of the problems of formwork, when evidently the architectural problem gives opportunity for a logical and economic application. On the other hand precasting, owing to its nature, means a renunciation of monolithism, which is one of the most peculiar characteristics of reinforced concrete, and therefore it is an apparent impossibility to use precast units for spacial structures.

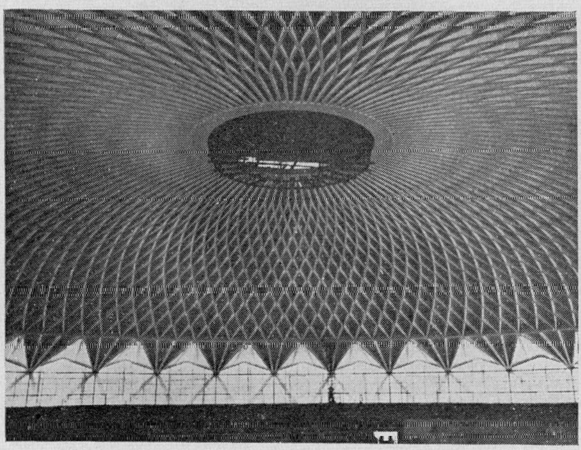

FIG. 1.—PIER LUIGI NERXI SPORT PALACE IN ROME—INTERIOR VIEW.

In this field again we have to recall Nervi, able to give back monolithism to the most complex precast units (See Fig. 1) but, as a future method worth serious consideration, we stress the possibility of a better and more complete use of prestressing technique.

As a matter of fact up to today prestressing is chiefly used to improve static possibilities of plane units but hardly is the spacial bond able to give back monolithism to precasting. The modern techniques of prestressing—among them I recall as particularly suggesting for our line of thoughts, the Zeiss Dywidag technique which can enable new ways of building (Fig. 2), can really enlarge in a big way the possibilities of precasting for spacial structures.

As another example of possibilities offered by properly using precasting and prestressing, I remember a thin cylindrical shell with elliptical directrix wth spans 45′ by 90′, having a membrane thickness of 2¼″ built by using precast joists in reinforced hollow bricks, tied together with a few prestressing cables acting mostly as sewing threads. The vault has been built using basic joists shown in Fig. 3 which allows a reinforcing in the direction perpendicular to the precasting direction, but use of hollow channels between bricks. By properly arranging those joists on a simple centering and by properly using pre-

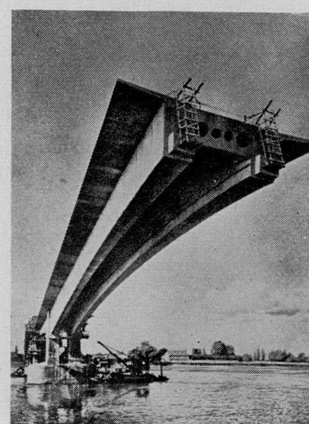

FIG. 2.—ZEISS DYWIDAG CONSTRUCTION OF WIDE BRIDGE SPANS BY MEANS OF PRESTRESSED UNITS.

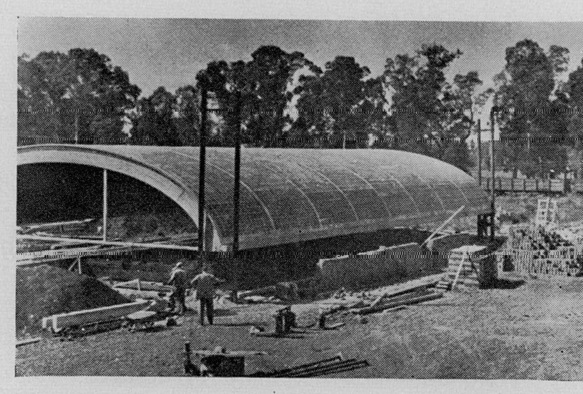

FIG. 3.—CYLINDRICAL SHELL SPANS 45′ x 90′ IN REINFORCED HOLLOW TILES.

stressing in edge generetrices and in a few other positions in the vault it has been possible to build the vault on the ground and lift it afterwards to the definitive position (Fig. 4) by means of four jacks operating on the supporting corners.

This kind of technique has given birth to several applications in the field of cylindrical shells. In these, the membrane units are precast

Fig. 4.—Skyscraper Pirelli in Milan.

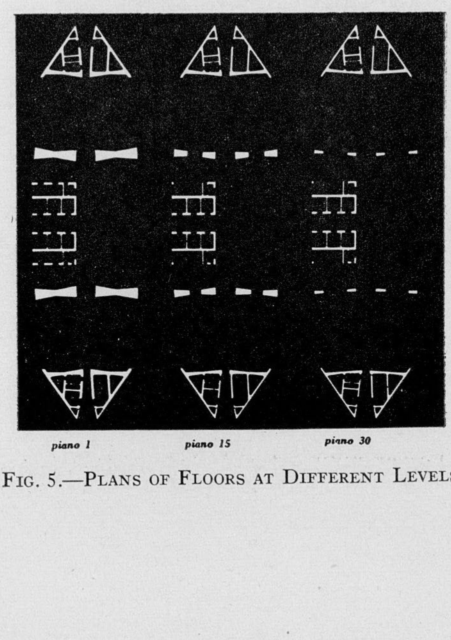

Fig. 5.—Plans of Floors at Different Levels.

according to the direction of curves and prestressing is used in edged beams, and transverse diaphragms (Fig. 5).

It is a technique which for the moment is used chiefly in simply curved shells but which lends itself also to double bent structures, if properly developed.

To complete our panorama we must remember—last but not least—that the spacial possibilities of reinforced concrete are not only in the field of curved structures but also in the field of wall beams, big box units, and in general in the clever combination of plates in every plane of space. For instance the modern Pirelli Skyscraper in reinforced concrete now under construction in Italy clearly shows the clever static conception followed by its designers.[1]

Due to an intelligent spacial distribution of reinforced concrete elements it has been possible to give to the building a maximum of inertia in the direction of predominating winds and a maximum of frame monolithism in the other direction, thus allowing quite big spans (45′ lateral span — 72′ central span) of outstanding architectural possibilities and aesthetic effect.

Reinforced concrete is really at the verge of an age of better exploitment of its possibilities. Let us believe in them and prepare ourselves. Even if our destiny is to ride on the river of life as rowers do, our eyes fixed on the past, our back towards the future, we must see and believe something more than the past we leave in front of us.

[1]Architect: Ponti. Structural Engineers: Nervi and Danusso.

JOHN F. FITZGERALD EXPRESSWAY TUNNEL SECTION

By Eric Reeves*

(Presented at a meeting of the Structural Section, B.S.C.E., held on February 12, 1958.)

Ten years ago the concept of a highway to relieve traffic congestion in downtown Boston was embodied in a Master Highway Plan, and funds for its design and construction were appropriated. By 1955, and after an expenditure of $35 million dollars, an elevated six lane highway with various attendant ramps, was opened to traffic and spanned the section from Charlestown to Fort Hill Square.

The constructon of this section was not without opposition, but with the concrete and steel giant poised for its half mile run through the business district fronting South Station, the opposition became formidable. Move it to the right, move it to the left, build it elevated, build it underground, build it anywhere, but not through my establishment. Under the able leadership of Commissioner John A. Volpe the various opposition groups were eventually reconciled, and a compromise was reached which put the highway underground and created a wide boulevard at grade which it was felt would enhance the existing business frontage and engender a rebirth of real estate in the general area (figure 1).

Factors in Design

The decision to project the highway in a vehicular tunnel posed many problems not present in the elevated type structure.

(A) *Access and Egress Ramps.*

The main trunk roadway would naturally have to be an extension of the already completed six lane divided highway, but this tunnel would differ from the accepted concept of the work in that there would have to be access and egress ramps from the tunnel itself to and from the City Streets. The South Station being one of the principal origination and destination points. The junction of these ramps with the main stem would in places make the over-all width of the tunnel as much as 150 feet and a clear span inside of as much

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as 75 feet. The normal over-all width for a 6-lane trunk line would be approximately 100 feet and a clear span inside of 45 feet. No tunnel of such width as the normal section, so far as we know, had ever been attempted, while the widened sections bordered on the fantastic.

FIG. 1.

(B) *Optimum Depth of Cover.*

It was hoped to keep the roof sufficiently below grade to allow passage of all utilities over the top, and at the same time keep the tunnel as close to the surface as possible to hold the ramp grades within the allowable. Furthermore, this tunnel would have to cross over the top of an existing Rapid Transit tunnel at South Station. The design, as later worked out, determined the average cover to be about three feet six inches (3′-6″), which figure was used in computing the dead load.

(C) *Uplift and Soil Pressure.*

Being near Boston Harbor borings showed that there would be full hydrostatic uplift. Therefore, the tunnel had to have sufficient weight to overcome floatation, which was actually another factor to be considered in the choice of cover of three feet six inches (3′-6″). It worked out later that the safety faction against uplifts was 1.2 and the weight of earth removed was approximately equal to the weight put back, so that the settlements should be a minimum.

(D) *The Design Load.*

A rather exhaustive study was made to determine what loading had been used in other instances, and some of the findings are tabled below:

(1) New York City Standard
- (A) 100 Ton Vehicle with 25 tons per wheel on 6 foot gauge and 12 foot axle spacing.
- (B) 1300 P.S.F. for 2 foot cover, with a minimum of 600 P.S.F. for 9 foot cover.

(2) Boston Transit Commission

$$L = \frac{28 - D}{.13} \quad (250)$$

where L = Load in P.S.F. and D = Depth of Cover.

(3) New York Transit Commission
- (A) 600 P.S.F.
- (B) 100 ton vehicle with 25 tons per wheel on 8 foot gauge with 12 foot axle.

(4) Seattle Battery Street Vehicular Tunnel
A.A.S.H.O. Bridge Loading of H20-S16

With only three feet six inches (3′-6″) of cover it was apparent that the heavy subway loads would place a severe penalty on the design of the normal section, and it was questionable if the widened sections could be designed at all.

Investigation failed to reveal any legitimate reason for such heavy loading as 1300 lbs., unless, as was suggested, it was to take care of the collapse of tall buildings. Could it be that the designers of the New York Subway system had actually anticipated the destructive blockbusters and the bomb shelter?

With Seattle Tunnel as precedent, the standard A.A.S.H.O. Bridge Loading of H20-S16 was adopted, but with further proviso that investigation be made of the effect of a 100 ton vehicle, allowing an increase of 25% in fiber stress.

Choice of Section

In general, cut and cover tunnels that had been designed were of basic sections:

(a) The reinforced concrete box

(b) The steel rib encased in concrete with the rib carrying all the stresses.

Had it not been for the widened sections and the limited cover, one or the other of these basic types would undoubtedly have been used. Two basic types, with modifications, variations and combinations were investigated in an attempt to arrive at the most equitable and most economical section for the location, keeping in mind the widening, the loading, the uplift and the limited cover.

The standard type steel rib frames. The frames are usually 5 feet on center, and are completely encased in concrete envelope. No composite action is assumed between steel and concrete in this design. This type of section has been used successfully in many of New York's cut and cover tunnels. Where spans are short, the roof beams are completely embedded, but usually the ceiling is jack-arched to reduce dead weight and still give full protection to the steel beams against corrosion and possible fire.

This section with the jack arch was estimated to cost $2,800 per foot for the normal section. This, of course, suggested a modification.

Modified.

The steel rib is utilized as before, but the invert or bottom beam is designed to act together with the concrete, which considerably reduced the size of the invert beam required. The jack arch also is dispensed with, and the steel roof beams left exposed. This section was estimated to cost $2,318 per linear foot and was finally adopted as the tunnel section for this project. Removing the roof beam encasements eliminated one of the large penalties for the long spans. The estimated saving was in excess of one million dollars on the entire project.

The Reinforced Concrete Box.

This type had been recently adopted for the vehicular subway in Seattle, Washington, and also for the Battery Park underpass in New York City, both of which have been built and are in service.

For normal width and loading, a good balanced section was designed, with 3 foot thick top and bottom slabs, 2 foot thick exterior walls, and a 1 foot thick center wall, at an estimated cost of $2,600 per linear foot. However, in the widened sections this slab thickness progressively increased to 5 feet and the corresponding estimated price to $5,000. With this thickness of roof no space would be available for utilities in the surface streets above. This condition immediately suggested the variation which is essentially a concrete box but has a prestressed concrete cover and estimated cost of $2,243 per linear foot. This economy was affected by employing two span prestressed, precast concrete rectangular beams for the roof (figure 2).

The economy of prestressed concrete in the normal sections was nullified in the transition sections where varying lengths precluded mass production and in the wide sections where the beams would have had to be cast in place, since the then practical limit of prestress precast without special anchorage was about 60 feet. Another disadvantage to this section was the difficulty of securing the top corners against articulation. Rotation of the joints would tend to break the waterproofing and would set up potential areas of leakage, which definitely was to be avoided.

The tunnel is comprised of approximately 470 ribs in a length of 2,400 feet, It is infinitely stiff in the plane of the ribs, but would have some flexibility in a longitudinal direction, since the tunnel has no steel backbone. This inherent flexibility will permit the tunnel to adjust itself to even bearing along the route, since soil conditions are not constant but varying from very hard to very soft. The real hard point was the M.T.A. crossing, where it was felt that a 24 inch sand cushion between between the two structures would allow for the minor adjustment settlements without throwing point loads to the M.T.A. structure or causing the tunnel to break its back if the two ends settled. There are no expansion joints between portals.

Typical Cross Section

As the steel frame is the rim, and the concrete envelope is the skin, the waterproofing membrane is the hide, and probably one of the most important components of the whole structure. Seepage, weepage and leakage are to be prevented at all costs.

Laid first to the soil is a 6 inch mud slab, and over the slab a one-ply membrane. On this membrane mastic is laid and hot bricks, and

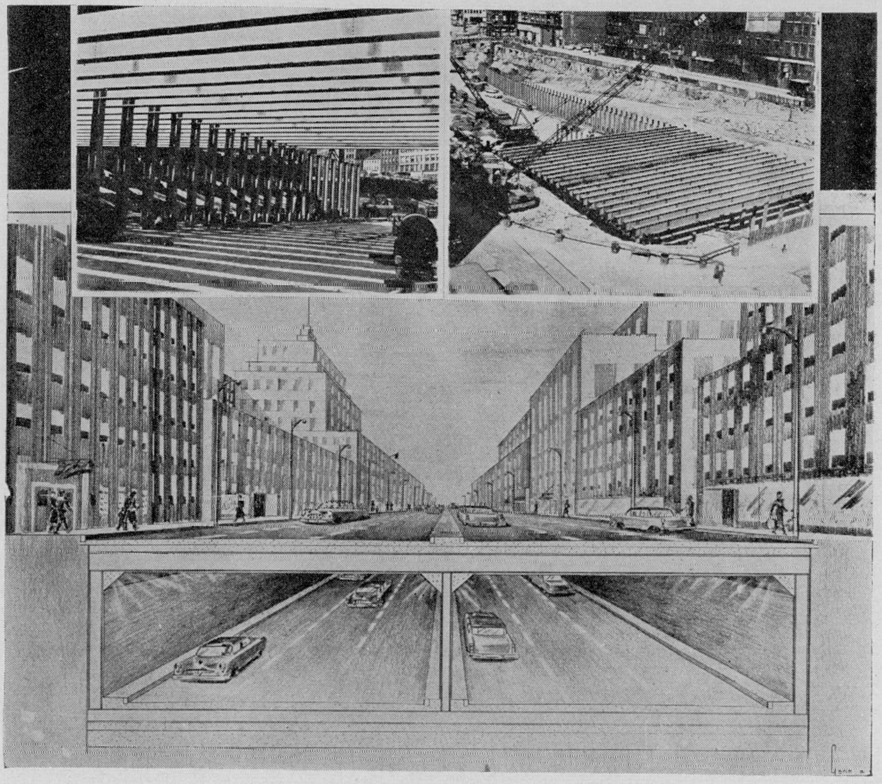

FIG. 2.

over and between the brick more mastic. The bricks are heated to drive out all moisture so they can absorb mastic in all pores. With bricks laid flat an equivalent of 2 inches of mastic is obtained. Brick and mastic is used because it is less vulnerable to construction hazards; such as nails, spikes and miscellaneous debris, having the ability to heal or be self-healing when the penetrating object is withdrawn, acting like a puncture-proof tire. The sides are covered with three-ply membrane and the roof with four-ply membrane. Each ply is asphalt mopped. The membrane is protected with brick on the sides and poured concrete on top. Mastic would also be ideal for the sides, but it is impossible to place it on vertical surfaces.

On the inside of the section, figure 3, is shown (a) the concrete between and encasing the invert beams providing the tunnel ballast as well as protecting these beams from corrosion and (b) the six inch wearing slab. In general, tunnels are paved with brick principally because repairs to the pavement can be quickly and effectively made at night when the traffic is not heavy. With the debut of the concrete saw, it is hoped that repairs can be made as conveniently in concrete pavements.

The pavements here will have sawed contraction joints about 20 feet on center. (c) The small depressed gutter, we hope, will carry away tunnel wash water only. Above the gutter is a steel armoured curb and narrow maintenance walk. No provision is made for a high patrol walk as in the New York tunnels. (d) Above the walk the walls will be covered with 4½ x 4½ ceramic tile. Tiles are used for two purposes: (1) to give a smooth surface for cleaning, and (2) to reflect light without glare.

Major Accessories

The three most essential accessories that go with tunnels are pumps, lighting and the ventilation system.

Pumps. In view of what has just been said about waterproofing, it would appear paradoxical to mention pumps. But—just in case—a pump house equipped with two 3600 g.p.m. pumps is added adjacent to each main portal. The pumps will be automatically actuated by float controls. The control is so wired that the pumps will operate alternately under normal conditions and together under emergency conditions.

The normal pump operation will take care of drainage from the two main approaches and the four ramp sections as well as the wash water, since the tunnel will be washed weekly.

Lighting. The tunnel will be lighted by continuous lines of fluorescent lamps mounted at the intersection of the walls and the roof. The fixtures consist of a pair of bronze castings 12 feet 6 inches on center connecting 2½ inch Pyrex tubes with gasketed watertight connections. Inside this large tube are two 6-foot slimline fluorescent tubes end to end in a single line. From experimental models it is

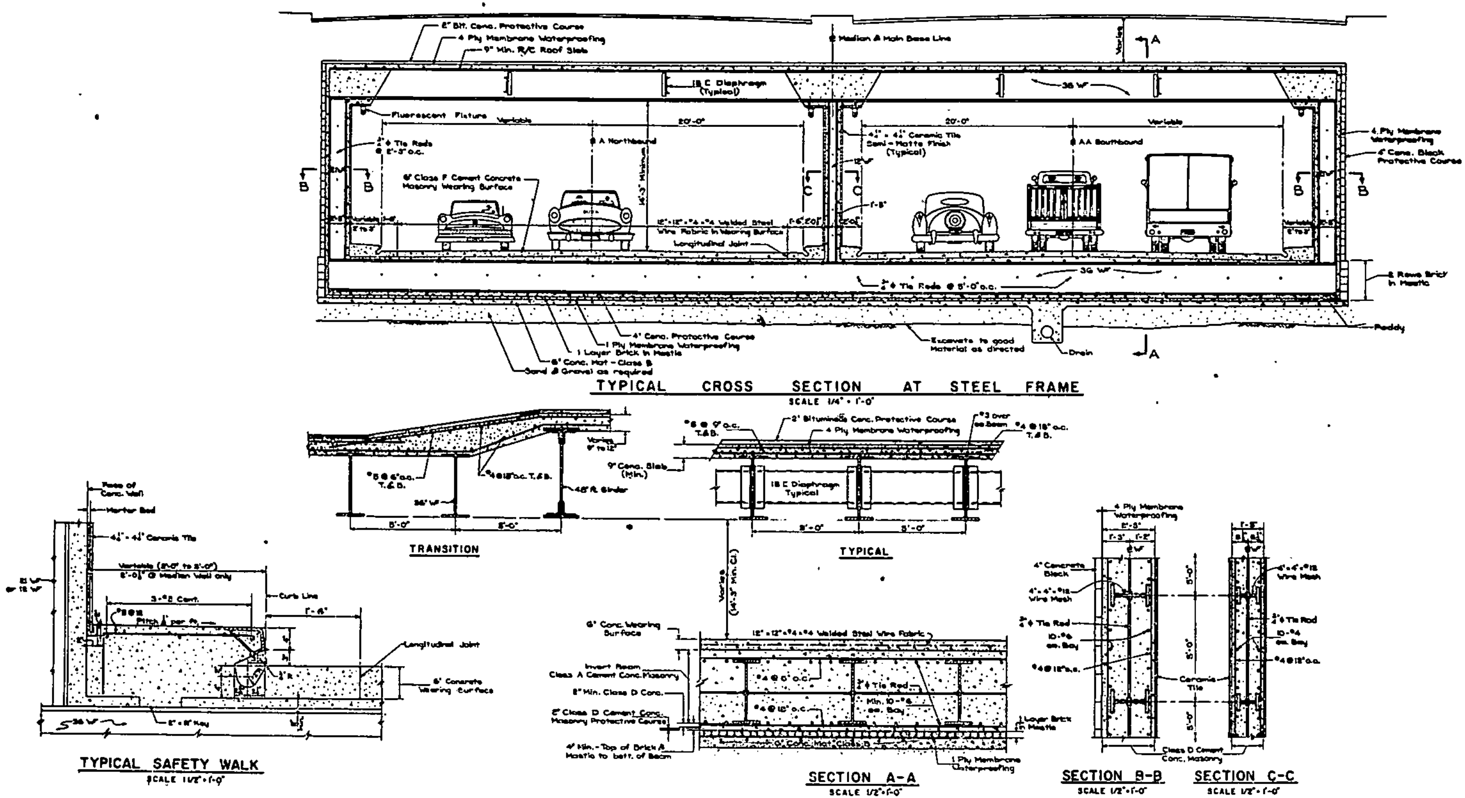
2" Bit. Conc. Protective Course
4 Ply Membrane Waterproofing
9" Min. R/C Roof Slab
18 C Diaphragm (Typical)
Fluorescent Fixture
Variable
20'-0"
A Northbound
AA Southbound
6" Class F Cement Concrete Masonry Wearing Surface
12"×12"–#4–#4 Welded Steel Wire Fabric in Wearing Surface
Longitudinal Joint
4 Ply Membrane Waterproofing
4" Conc. Block Protective Course
2 Rows Brick in Mastic
¾" φ Tie Rods @ 5'-0" o.c.
4" Conc. Protective Course
1 Ply Membrane Waterproofing
1 Layer Brick in Mastic
6" Conc. Mat – Class B
Sand & Gravel as required
Excavate to good Material as directed
Drain
Paddy
TYPICAL CROSS SECTION AT STEEL FRAME
SCALE 1/4" = 1'-0"
TRANSITION
TYPICAL
TYPICAL SAFETY WALK
SCALE 1 1/2" = 1'-0"
SECTION A-A
SCALE 1/2" = 1'-0"
SECTION B-B
SCALE 1/2" = 1'-0"
SECTION C-C
SCALE 1/2" = 1'-0"

FIG. 3.

expected that the illumination will be a minimum of 5-foot candles at the curb line, which is about 5 times the intensity of regular highway lighting.

Near the entrance portals, the fixtures will be doubled to increase the intensity and make the transition from daylight to tunnel more gradual and easier for motorists. In widened sections an additional row of tubes is carried in the center.

To guard against normal power failures the lights are so wired that every third fixture is on a separate circuit. In this way a minimum of one-third of the lights would always be on. These lighting circuits are fed from two independent power loops—the equivalent of four independent feeds from two power stations.

The light output from the tubes can be varied by means of saturable reactors. At night the lighting on the pavement in the tunnel would be reduced to the same intensity as that on the approach section outside. This, over the years, will amount to a substantial saving in the power bill.

Ventilation. A carbon monoxide concentration of .06% or 6 parts in 10,000 can cause a headache in less than one hour and unconsciousness in two hours. Likewise, a .1% or 10 parts in 10,000 may produce unconsciousness in one hour and death in two hours. Higher concentrations may cause death in a matter of minutes.

In vehicular tunnels all ventilation systems are designed to keep this CO concentration below two parts in 10,000, well below the death curve. This can be accomplished by introducing fresh air, exhausting contaminated air or combining both. The ideal ventilation is to inject air at the curb line with sufficient force to sweep the pavement, curve up the far wall, back across the roof and be exhausted at an exit port in the roof line directly over the input (figure 4) . This air then circulates, always at right angles to the traffic flow. It is brought to and exhausted from the tunnel ports in large ducts running parallel with the tunnel and exchanged in a single ventilation building midway on the tunnel system. Such systems are in use in the Holland Tunnel, the Lincoln Tunnel and the Sumner Tunnel. To have employed this system here would have further widened the already wide tunnel to provide for the two longitudinal supply and exhaust ducts which would have replaced the center wall. This would mean taking of additional real estate on either side, which in some cases was not economically feasible. Satisfactory systems using air flowing longitudinally with the traffic had recently been employed in the Seattle Tunnel and in the Battery Park Underpass. Air was forced in under pressure and allowed to drift towards the tunnel portals. For maximum efficiency the air should be introduced at many points. This was accom-

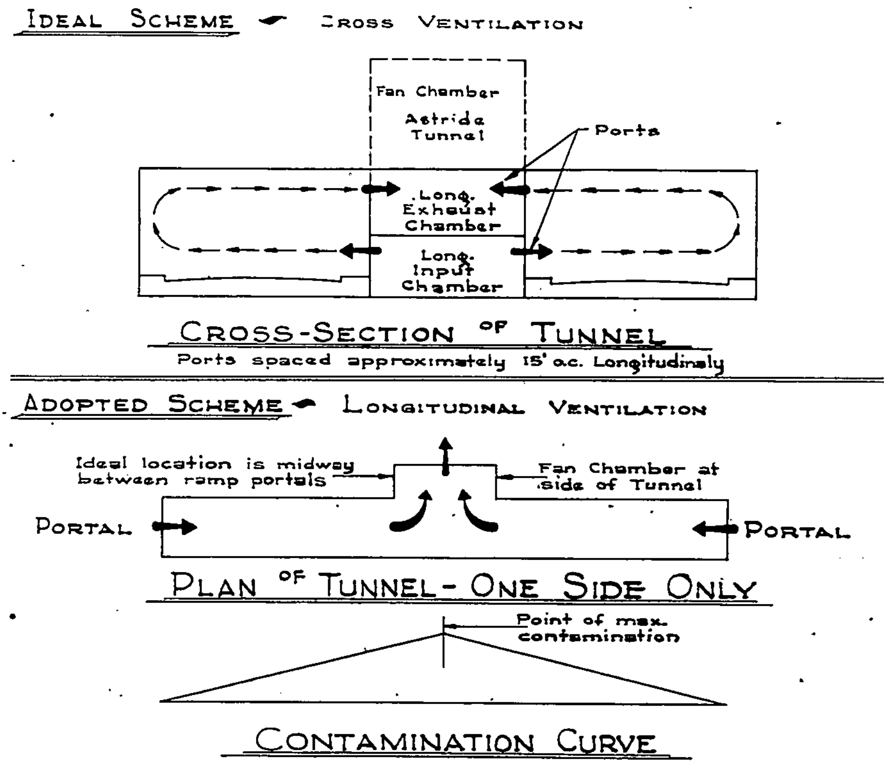

FIG. 4.

plished in Seattle by a multiplicity of small fans located on the roof. The fans were caged in small protective structures. Due to the possibility of heavy snowfalls in the Boston area blocking the vents and the vulnerability of the cages to traffic on the surface road, the multiple injection system was discarded. Instead, it was decided to exhaust the air, using the portals as supply points and placing the exhaust system midway between two adjacent portals. The location of the ramps naturally and conveniently divided the tunnel into four complete systems. With four ventilation chambers almost 3 million cubic feet of air can be exhausted per minute, or an average of ¾ million C.F.M. per chamber with all fans running full speed.

From experience in other projects it is known that, in order to keep the CO content within tolerable limits, a ventilation system must supply or extract approximately 100 C.F.M. of air per lineal foot of traffic lane. The fan chambers were designed on this basis. The fans are of the axial flow propeller type since the static pressure is small and the air is to be removed only from atmospheric pressure to atmospheric pressure through the exterior wall. The approach velocity is kept low, about 500 ft. per minute, and the exist velocity high, about 3,000 ft. per minute. The approach velocity is kept low intentionally so as not to inconvenience motorists, particularly the fair sex in the open cars. Exit velocity is kept high to reduce the size of discharge stack, the only limitation being the noise. In this case the top noise level was set as 92 decibels. Maximum fan operation and the consequent noise will occur during the maximum rush hours, 7 to 8 a.m. and 5 to 6 p.m., hence the reason for setting such a high noise level. Four CO samples will be taken from the points of expected maximum concentration, one for each chamber. The samples are automatically recorded on a visual graph for the operator's convenience. The operator will manually operate the 22 fans, as dictated by this concentration. Since the fans are also two-speed, the operator will have 44 combinations at his command, giving him an almost precision adjustment. Automatic control is not recommended because the fans will have a tendency to "hunt".

Minor Accessories

(a) *Fire Protection*: Should fire break out in the tunnel, hose connections for the fire department are provided along the center wall for each roadway. The supply pipe for these connections is normally dry, to guard aganst freezing in winter. Supply valves are located at all access portals so that if one fireman is dropped off at the valve, as the apparatus enters, the supply pipe should be full by the time the hose are connected.

CO_2 fire extinguishers are also placed in cabinets along the wall for emergency use. There will also be fire alarm boxes as well as trouble telephones. Probably of most value to the motorists are the escape doors in the center wall which will allow them to enter and escape through the adjacent section.

Auxiliary Construction

(a) *Underpinning*: All adjacent buildings along the route of the tunnel were underpinned if the foundations protruded inside a 45° line drawn from the bottom of the tunnel towards the building. The Contractor had the choice of using the alternate pit method or the jack pile. He elected to use the latter in all cases except the Albany building, where an interesting variation was used. Here, instead of jacking three expensive piles he proposed to jack one inside the building and drive two outside the building, which were bridged and used to pick up the needle to the third pile, a good example of contractor's ingenuity.

(b) *Metropolitan Transit Authority*: Near the South Station it was necessary to remove the arched roof of the M.T.A. Subway. Prior to the tunnel contract the M.T.A. had let a contract to install a system of falsework inside the subway tunnel and relocate stairways and escalators. This falsework was located at the spring line, and consisted of 6-inch wood plank on steel beams. This would serve as form work when pouring the new roof and would prevent debris from falling in the tunnel during the alteration period. A portion of the subway station was also demolished and revisions were made to the stairway and escalators.

Utilities

As might be expected, the tunnel severed all utilities in its path—water, sewerage, power, light, telephone and gas. By using steel welded pipe and eliminating flanges it was possible to relocate many of the utilities in permanent position in the cover space between the surface road and the top of the tunnel. There were two exceptions—the sewerage and the power transmission lines. The sewers were intercepted and by-passed around the portals and under the shallow approach sections to avoid using inverted syphons under the tunnel. The power lines were carried in small tunnels underneath the traffic tunnel since the company claimed the use of the shallow cover over the top would have increased cable heat losses and decreased power transmission.

Quantities and Costs

The construction cost of the tunnel, including the north approach, was approximately $17,000,000. Of this amount 3½ million was for 17,250 tons of structural steel for the ribs. Some of the major quantities are listed as follows:

Excavation	441,254	C.Y.
Concrete	117,100	C.Y.
Reinforcing Steel	7,259,600	Lbs.
4-Ply Membrane	48,500	S.Y.
Brick in Mastic	3,088	C.Y.
Ceramic Tile	160,000	S.F.
Ventilating System	$90,000.	
CO Analyzer	$20,000.	
Electrical Work	$1,175,000.	
Underpinning	$329,000.	

Engineers and Contractors

The designs were made by the Joint Venture firms of Charles A Maguire and Associates and Fay, Spofford and Thorndike for the Massachusetts Department of Public Works. The general contractor was the V. Barletta Company.

OF GENERAL INTEREST

STUDENT NIGHT

WEDNESDAY EVENING, OCTOBER 23, 1957.—The forty-seventh annual Student Night Meeting of the BSCE in cooperation with the ASCE Massachusetts Section was held at Northeastern University.

The speaker was Dr. Karl Terzaghi, Professor of the Practice of Civil Engineering and Professor Emeritus of Civil Engineering at Harvard University, who spoke on the "Use and Abuse of Consultants in Foundation and Earthwork Engineering".

A roast beef dinner was enjoyed before the meeting by more than 400 students, professional engineers and guests. A record attendance of over 436 was present at the meeting which was presided over by the president of the BSCE, Dr. Arthur Casagrande.

The Student Chapter of the BSCE, ASCE, of Northeastern University held open house in their recently renovated Civil Engineering Bldg. previous to the dinner and also conducted tours throughout the university for visitors. Coffee was served in the society room and fellow students of Civil Engineering were welcomed from Tufts Univ., M.I.T., Harvard, Brown, Dartmouth, Worcester Polytech., Univ. of Rhode Island, Yale, Univ. of Mass.

Dr. Terzaghi's paper and a number of discussions were published in the January 1958 JOURNAL. Other discussions together with Dr. Terzaghi's closing remarks will be published in the July 1958 JOURNAL.

Seated, left to right: Mrs. Karl Terzaghi; Dr. Karl Terzaghi; Professor Arthur Casagrande, Pres. B.S.C.E.; Mr. A. Russell Barnes, Pres. Mass. Section A.S.C.E.; Mr. Donald Ross; Mrs. Donald Ross; Mr. Robert W. Moir.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETING

Boston Society of Civil Engineers

JANUARY 22, 1958.—A Joint Meeting of the Boston Society of Civil Engineers with the Sanitary and Hydraulics Sections of BSCE was held this evening at the United Community Services Building, 14 Somerset Street, Boston, Mass., and was called to order by Vice President William L. Hyland, at 7:20 P.M.

Vice President Hyland announced that the minutes of the previous meeting held December 18, 1957 would be published in a forthcoming issue of the JOURNAL and that the reading of the minutes of that meeting would be waived unless there was objection.

Vice President Hyland announced the death of the following member:—

Charles W. Sherman, elected a member November 20, 1895, elected Honorary Member February 19, 1947 and served as Vice President March 1917 to March 1919, and who died January 17, 1958.

The Secretary announced the names of applicants for membership in the BSCE and that the following had been elected to membership January 20, 1958.

Grade of Member—Kenneth M. Childs, Jr., James F. Haley, Donald T. Fairburn, Francis J. Mardulier, Thomas A. Faulhaber.

Vice President Hyland requested the Secretary to present a recommendation of the Board of Government to the Society for action. The Vice President stated that this matter was before the Society in accordance with the provisions of the By-Laws and notice of such action published in the ESNE Journal dated January 13, 1958.

The Secretary presented the following recommendation of the Board of Government to the Society for initial action to be taken at this meeting.

As a consequence of a number of unanticipated expenditures during this fiscal year an amount approaching, but not exceeding $6000 is needed to balance the Secretary's budget. Therefore the Board of Government voted, December 16, 1957 "to recommend to the Society that the Board of Government be authorized to transfer an amount not to exceed $6000 from the Principal of the Permanent Fund to the Current Fund for current expenditures".

On motion duly made and seconded it was *VOTED* "that the Board of Government be authorized to transfer an amount not to exceed $6000 from the Principal of the Permanent Fund to the Current Fund for current expenditures".

Vice President Hyland stated that final action on this matter would be taken at the February 19, meeting of the Society.

Vice President Hyland stated that this was a Joint Meeting with the Sanitary and Hydraulics Sections and called upon John F. Flaherty, Chairman of the Sanitary Section to conduct any business matters necessary for that Section and also called upon Clyde W. Hubbard, Chairman of the Hydraulics Section to conduct any business matters for that Section at this time.

Vice President Hyland then introduced the speakers of the evening, Professor Arthur A. Maass, Assoc. Prof. of Government, Graduate School of Public Administration, Harvard University, and Mr. James S. King, Civil Engineer, Corps of Engineers, North Central Division, U.S. Army, who gave a "Symposium on Water Resource Development."

A lively discussion followed the talk.

The meeting was preceded by a dinner and 84 members and guests attended the dinner. 133 members and guests attended the meeting.

The meeting adjourned at 9:20 P.M.

ROBERT W. MOIR, *Secretary*

FEBRUARY 19, 1958.—A Joint Meeting of the Boston Society of Civil Engineers with the Structural Section, B.S.C.E., was held this evening at the United Community Services Building, 14 Somerset Street, Boston, Mass., and was called to order by President, Arthur Casagrande, at 7:15 P.M.

President Casagrande announced the death of the following members:—

Amos L. Perkins, who was elected a member December 16, 1953 and who died January 29, 1958.

Frank L. Flood, who was elected a member January 25, 1922 and who died February 14, 1958.

The Secretary announced the names of applicants for membership in the BSCE and that the following had been elected to membership February 18, 1958.

Grade of Member—Homer B. Briggs, Guy Denizard, George L. Medding, Donald H. Mooney, Duncan S. Pearson, Robert E. Price, Armand E. Provost, Jr., Peter J. A. Scott, Clinton A. Shibles, Fred T. Stetson.

Associate Member—R. S. Goyal, Rupert W. Kilgour.

Junior Member—Henry D. Shanks, Gerald L. Woodland, Jr., Herrick H. Spicer, Charles T. Gwinn.

President Casagrande requested the Secretary to present a recommendation of the Board of Government to the Society for action. The President stated that this matter was before the Society in accordance with provisions of the By-Laws and notice of such action published in the ESRE Journal dated February 10, 1958.

The Secretary presented the following recommendation of the Board of Government to the Society for final action to be taken at this meeting.

As a consequence of a number of unanticipated expenditures during this fiscal year an amount approaching, but not exceeding $6000 is needed to balance the Secretary's budget. Therefore the Board of Government voted, December 16, 1957 "to recommend to the Society that the Board of Government be authorized to transfer an amount not to exceed $6000 from the Principal of the Permanent Fund to the Current Fund for current expenditures".

On motion duly made and seconded it was *VOTED* "that the Board of Government be authorized to transfer an amount not to exceed $6000 from the Principal of the Permanent Fund to the Current Fund for current expenditures".

President Casagrande stated that this is the final action on this matter.

President Casagrande stated that this was a Joint Meeting with the Structural Section, BSCE and called upon John M. Biggs, Chairman of that Section to conduct any necessary business at this time.

President Casagrande then turned the meeting over to Henry A. Mohr, Moderator, to conduct the Forum Discussion on "Revision of Part 29, Foundations, of the Boston Building Code".

Those participating in the discussion included Dr. Arthur Casagrande of Harvard, Henry A. Mohr, Consulting Engineer, Mr. Cummings of Bethlehem Steel Company, Abraham Woolf, Consulting Engineer, Mr. Mann of the Wood Preservers Assn., Roy N. Brodie of the B. & M. R.R., Maurice A. Reidy and Maurice A. Reidy, Jr., of M. A. Reidy Company, Paul S. Crandall of Crandall Dry Dock Engineers, Prof. James E. Roberts of M.I.T., Miles N. Clair of Thompson & Lichtner and Simon Kirshen of Clarkeson Engineering.

The meeting was preceded by a dinner and 58 members and guests attended the dinner. 97 members and guests attended the meeting.

The meeting adjourned at 9:30 P.M.

ROBERT W. MOIR, *Secretary*

MARCH 19, 1958.—The one hundred tenth 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 4:12 P.M., by President Arthur Casagrande.

President Casagrande announced that the reading of the minutes of the Society meetings had been omitted during the year. The minutes of the January and February meetings will be published in a forthcoming issue of the JOURNAL. The minutes of the April, May, October, November and December meetings to be declared approved as published.

It was VOTED "to approve the minutes as published".

The Secretary announced that the following had been elected to membership:—

Grade of Member—Andrew Canzanelli, Jr., Anthony J. Canon,* Charles H. Flavin, Jr.,* Albert J. Gravallese, Jacques Naar.

Grade of Associate—Arthur Adams.

The Secretary also announced the names of applicants for membership in the Society.

The Annual Reports of the Board of Government, Treasurer, Secretary and Auditors were presented. Reports were also made by the following committees—Hospitality, Library, John R. Freeman, Membership, Advertising, and Joint Legislative Affairs Committee.

It was *VOTED* "that these reports be accepted and placed on file".

The Annual Reports of the various Sections were read and it was VOTED "that the Annual Reports of the various Sections be accepted and placed on file".

President Casagrande stated that all foregoing reports would be published in the April issue of the JOURNAL.

The Report of the Tellers of Election, Charles M. Anderson and Roland S. Burlingame was presented and in accordance therewith the President declared the following had been elected officers for the ensuing year:

President William L. Hyland
V-President (for two years)
Edward C. Keane
Secretary (for one year)
Robert W. Moir
Treasurer (for one year)
Charles O. Baird, Jr.
Directors (for two years)
Joseph C. Lawler
Cas. J. Kray
Nominating Committee (for two years)
John M. Biggs
Paul A. Dunkerley
William A. Henderson

The retiring President Arthur Casagrande then gave his address entitled "A European View of the American Educational Crisis".

Forty members and guests attended the business meeting.

The meeting adjourned to assemble at 8:00 P.M. the Annual Dinner being held during the interim.

The President called the meeting to order at 8:00 P.M.

Following general remarks and the introduction of the newly elected President, William L. Hyland, and other guests at the head table the various prize awards were made.

The Secretary read the various prize awards and asked the recipient to come forward and President Casagrande presented the awards. (See page 178.)

The Secretary described Scholarship and asked recipients to come forward and the President presented the following Scholarships:

Desmond FitzGerald Scholarship to Bruce N. MacIver, Student at Northeastern University.

Award	*Recipient*	*Paper*
Desmond FitzGerald Medal	Howard Simpson	"The New ACI Code—Its Implications and Ramifications".
Clemens Herschel Award	Robert J. Basso) Frank L. Lincoln) Joseph Peraino)	"Rehabilitation of Wharves and Piers—Army Base, South Boston, Mass.
	Saul Namyet	"Analog and Digital Computers in Civil Engineering".
Structural Section Award	Harl P. Aldrich, Jr.	"Site Preloading Eliminates Piles for Two Oil Storage Tanks".
Transportation Section Award	Ernest H. Herzog	"A Forward Look in Transportation".
Student Chapter Prize Award	Alfred J. Schiff	"Examination of Private Water Supplies by the Massachusetts Department of Public Health".

William P. Morse Scholarship to Walter B. Landin, Student at Tufts University.

President Casagrande then introduced the speaker of the evening, Dr. Paul A. Siple, Chief of Research Development, U.S. Army, Washington, D.C., who gave a most interesting illustrated talk on "Construction and Maintenance of the IGY South Pole Station".

At the conclusion of the address President Casagrande on behalf of the Society thanked Dr. Siple for a most enjoyable talk and then turned the meeting over to President elect William L. Hyland.

President elect William L. Hyland presented retiring President Arthur Casagrande with a certificate for services rendered and then adjourned the meeting.

Two hundred members and guests attended the dinner meeting.

ROBERT W. MOIR, *Secretary*

STRUCTURAL SECTION

FEBRUARY 12, 1958.—A meeting of the Structural Section was held in the Society rooms this evening. Chairman Biggs called the meeting to order at 7:15 P.M. The minutes of the previous meeting were read and approved. Mr. Biggs announced that at the March meeting Dr. Lauritz Bjerrum, Visiting Professor at Massachusetts Institute of Technology, would speak on the Construction of Tunnels in Soft Clay. Mr. Biggs announced the names of Dr. Ruth Terzaghi and Cas. J. Kray and A. L. Delaney as members of the Nominating Committee of the Section. The list was approved.

Mr. Edward C. Keane of Fay, Spofford & Thorndike reviewed the general highway layout as recommended for the City of Boston in the original Master Plan. He stated that recent studies of highway needs in Boston confirm the advantages of the Master Plan, but suggest the addition of two radial routes.

Mr. Eric Reeves spoke on the design of the Tunnel Section of the Central Artery. The cover over the tunnel has been kept as small as possible consistent with the passage of utilities over the tunnel. The normal clear span of three traffic lanes inside the tunnel is 45 feet, but where ramps occur, clear spans are considerably greater. Several types of cross-section were studied and the design finally selected consisted of a series of transverse steel frames with a slab resting on the roof beams, and with the remainder of the frames encased in concrete to form a continuous tunnel. The roadway surface in the tunnel is concrete rather than the brick generally used in the New York tunnels. Lighting is fluorescent with 5 foot candle intensity increasing to greater intensities at entrances and exits. Fresh air is drawn in at the portals and foul air is exhausted by batteries of fans at the center of the tunnel.

Slides showing the construction of the tunnel were shown, and the meeting adjourned at 9:05 P.M.

Attendance was 72.

WILLIAM A. HENDERSON, *Clerk*

MARCH 12, 1958.—A meeting of the Structural Section was held in the Society Rooms this evening. Chairman Biggs called the meeting to order at 7:00 P.M. Mr. A. W. Delaney read the report of the nominating committee as follows:

Chairman	Richard W. Albrecht
V-Chairman	William A. Henderson
Clerk	Paul S. Crandall
Executive Committee	Myle J. Holley
	John C. Rundlett
	Edward N. Smith

A motion was made, seconded and carried that the chairman cast one vote for the slate as presented, and the nominees were duly elected. Mr. R. W. Albrecht announced that the next meeting would be held on April 9 in the Society Rooms, at which time, Mr. Ralph H. Gloss, Vice President of the Timber Engineering Company, would be the speaker and would present a film entitled "Coming Out of the Woods".

Mr. Biggs introduced the speaker of the evening, Dr. Lauritz Bjerrum, visiting professor at Massachusetts Institute of Technology, whose subject was "The Construction of a Tunnel in Soft Clay", in Oslo. Dr. Bjerrum is a member of a newly appointed Norwegian Geophysical Bureau, which was requested to design a vehicular tunnel in Oslo. The tunnel was to be built partly in ledge and partly in deep valleys of extremely sensitive soft clay. It was to be located under city streets where, because of traffic conditions, open excavation could be allowed for only short periods. The adopted design required, first, open excavation to the depth of the proposed tunnel roof. Steel sheeting was then driven along the sides of the excavation and down to an elevation well below the proposed tunnel floor. The tunnel roof was then poured at the bottom of the excavation and directly on top of the sheeting. Thereafter under compressed air the clay below the roof and between the sheeting was excavated and the floor slab was placed. Finally the center and side walls were poured. Details for eliminating the effect of differential settlement have not yet been worked out, and it is possible that the complete tunnel may be prestressed longitudinally.

After a question period, the meeting was adjourned at 8:30 P.M.

Attendance—52.

PAUL S. CRANDALL, *Clerk*

HYDRAULICS SECTION

FEBRUARY 5, 1958.—A meeting of the Hydraulics Section was held at the Society Rooms, 20 Pemberton Square, Boston, Mass., and was called to order by Clyde W. Hubbard, Chairman, at 7:10 P.M.

The minutes of the meeting of November 6, 1957 were read and approved.

The Chairman announced the possibility that Dr. Henry M. Paynter would address a September meeting on the subject—"Hydraulic Transients in the M.D.C. Tunnels".

Mr. Joseph C. Lawler, Chairman of the Nominating Committee, presented the following slate of officers for the coming year:

Chairman James W. Daily
V-Chairman Lee M. G. Wolman
Clerk John B. McAleer
Executive Committee
Lawrence C. Neale
Donald R. F. Harleman
Clifford S. Mansfield

The above slate was elected by unanimous consent.

The Chairman introduced the speaker, Lawrence C. Neale, Asst. Prof. of Hydraulics, Worcester Polytechnic Institute, whose subject was "Use of River Models in Cooling Water Studies".

Mr. Neale's talk covered recent research with outdoor models at the Alden Hydraulic Laboratory, Worcester Polytechnic Institute, under the supervision of Professor L. J. Hooper. He described and showed photographs of the large models which varied from 100 to 120 feet in length and from 16 to 25 feet in width. He discussed the dimensional and temperature scaling and the instrumentation of the models. One of the features of the model setup is a high tower which permits "aerial" photographing of the model in operation. The speaker showed sequences of excellent colored slides which illustrated the partial mixing of warm, fluorescin-dyed return condensing water with river water and the recirculation of this heated mixture back to the intake. The speaker stated that there was good agreement between model and prototype where observations on the latter had been made. He also stated that the models were well adapted to silting studies. A lively question and discussion period followed the talk.

The Chairman turned the meeting over to the Chairman-elect who invited suggestions from all members of the Section for next year's meetings.

Total attendance at the meeting was thirty-five.

The meeting adjourned at 8:30 P.M.

LEE MAR G. WOLMAN, *Clerk*

SURVEYING & MAPPING SECTION

APRIL 10, 1957.—The thirty-third meeting of the Surveying and Mapping Section was held as a joint meeting with the Structural Section, B.S.C.E., in the Society Rooms and was called to order at 7:00 P.M., by John F. Biggs, Chairman of the Structural Section, who called upon Ernest A. Herzog, Chairman of the Surveying and Mapping Section to conduct any business necessary for that section at this time.

Chairman Biggs then introduced the speaker of the evening, Commander E. R. Foster. Commander Foster gave a fine introduction to the film "The Story of the Erection of Texas Tower No. 2 at Georges Bank". The film was most interesting and at its conclusion there was a question and answer period.

The meeting was adjourned shortly before 9:00 P.M. There were twenty-four members and guests present.

NELSON W. GAY, *Clerk*

OCTOBER 17, 1957.—The thirty-fourth meeting of the Surveying and Mapping Section was held at the Society Rooms at 8:00 o'clock P.M.

The meeting was called to order by Mr. Ernest A. Herzog, Chairman of the Section. The minutes of the April 10, 1957 meeting were read and approved.

The topic of the evening was "Unusual Problems In Surveying And Their Solutions".

Mr. Herman Shea spoke on the Declination of the Magnetic Needle and of Aerial Photographs for transmission lines.

Mr. Winfield Scofield explained an unusual solution in the three point fix.

Mr. Gordon Ainsworth spoke on the problem of trespass on private property and the need of good public relations by Party Chiefs.

Mr. Louis Chase, being ill and unable to attend had prepared a paper on location of interior steel and columns for the planning of elevators or escalators. This paper was read by the clerk.

Some personal experiences by the guests were given from the floor.

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

NELSON GAY, *Clerk*

JANUARY 16, 1957.—The thirty-fifth meeting of the Surveying and Mapping Section was held at the Society Rooms at 7:00 o'clock P.M. on Wednesday, January 15, 1958.

The meeeting was called to order by Mr. Ernest A. Herzog, Chariman of the section. The minutes of the October meeting were read and approved. Mr. Wilbur Mylander, Chairman of the Nominating Committee, read slate of nominees for the officers for the coming year. The slate nominated, accepted and duly voted in was as follows:

Chairman	George A. McKenna
Vice Chairman	Nelson W. Gay
Clerk	Charles L. Miller
Executive Committee	
	Roy L. Wooldridge
	Rudolf S. Slayter
	Alexander Manning

The speaker of the evening, Mr. Robert Thurrell, Field Engineer, Tellurometer Inc., Washington, D.C., was introduced by Mr. Herzog.

Mr. Thurrell spoke on the Tellurometer Electronic Distance Measuring System" and also had with him a set of these instruments to illustrate many of the points in his talk.

The instruments are portable, work under most any weather conditions, day or night and have a very high degree of accuracy. The instruments had been tested at M.I.T. during the day on a line "Brigham" to M.I.T. which according to U.S.C&G.S. has a distance of 11686.94 ft. and by "Tellurometer" measured 11687.03 ft.

The talk was most interesting and at its conclusion there was a question and answer period.

The meeting was adjourned at 8:15 P.M. There were 28 members and guests present.

NELSON GAY, *Clerk*

ADDITIONS

Members

James P. Archibald, 54 Delmar Avenue, Framingham, Mass.
Homer B. Briggs, 471 Nahatan Street, Norwood, Mass.
Andrew Canzanelli, Jr., 477 Appleton Street, Arlington 74, Mass.
Kenneth M. Childs, Charlesdale Road, Medfield, Mass.
Guy Denizard, 82 Jersey Street, Boston 15, Mass.
Donald T. Fairburn, 328 Harvard Street, Cambridge, Mass.
Thomas A. Faulhaber, 100 Memorial Drive, Cambridge, Mass.
Albert Gravallese, 119 Ashcroft Road, Medford 55, Mass.
James F. Haley, Haley & Aldric, 238 Main Street, Cambridge 42, Mass.
Simon Kirshen, 12 Maple Avenue, Cambridge 39, Mass.
Francis J. Mardulier, 37 Woodside Road, Winchester, Mass.
Jacques Naar, 624 Lynnfells Pky., Melrose 76, Mass.
Duncan Pearson, 88 Lewis Avenue, Walpole, Mass.
Robert E. Price, 99 Brook Road, Sharon, Mass.
Peter J. A. Scott, 51 Bird's Hill Avenue, Winthrop, Mass.
Clinton A. Shibles, 387 Revere Street, Winthrop, Mass.
Fred Stetson, 40 Glen Avenue, Brockton 28, Mass.
Lawrence J. Tierney, 120 Woodard Road, W. Roxbury 32, Mass.
Robert P. Weis, 2 Blueberry Lane, Holden, Mass.
James F. Regan, 25 Beaufort Avenue, Needham 92, Mass.
George L. Medding, 4 Appleton Park, Ipswich, Mass.

Associate

R. S. Goyal, 527 East Jefferson, Fort Wayne, Indiana

Rupert Kilgour, Pine Street, Ipswich,

Junior

Gerald L. Woodland, Jr., 136 Vinal Street, Revere, Mass.

Henry D. Shanks, 191 Lincoln Street, Brockton, Mass.

DEATHS

Charles W. Sherman, January 19, 1958.
Amos L. Perkins, January 29, 1958.
Frank L. Flood, February 14, 1958.
Francis W. Hamilton, February 25, 1958.

ANNUAL REPORTS

REPORT OF THE BOARD OF GOVERNMENT FOR YEAR 1957-1958

Boston, Mass., March 19, 1958

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, 1958.

The following is a statement of the status of membership in the Society.

Honorary	6
Members	976
Associates	6
Juniors	85
Students	7
Total	1,080
Student Chapters	2

Summary of Additions

New Members	53
New Juniors	25
New Associates	1
New Students	3

Reinstatements

Members	1

Summary of Transfers

Junior to Member	6

Summary of Loss of Members

Deaths	18
Resignations	14
Dropped for non-payment of dues	23
Dropped for failure to transfer	3

Life Members	109
Members becoming eligible today for Life Membership	7
Remission of dues	1
Applications pending on March 19, 1958	19

Honorary Membership is as follows:

Frank M. Gunby, elected, February 15, 1950
Karl R. Kennison, elected, February 7, 1951
Charles M. Spofford, elected, December 19, 1945
Karl Terzaghi, March 3, 1952
Howard M. Turner, elected, February 18, 1952
William F. Uhl, elected, February 7, 1955

The following members have been lost through death:

Louis A. Chase, Nov. 3, 1957
Horace L. Clark, Mar. 3, 1957
John R. Dyer, Dec. 15; 1957
Frank L. Flood, Feb. 14, 1958
Robert Gillespie, Oct. 5, 1957
Arthur E. Harding, Oct. 4, 1957
Francis W. Hamilton, Feb. 25, 1958
Parker Holbrook, July 3, 1957
Edward F. Kelley, Oct. 28, 1957
Henry L. Kennedy, Sept. 10, 1957
Chester A. Moore, Sept. 18, 1957
James M. McNulty, May 11, 1956
Amos L. Perkins, Jan. 29, 1958
Robert W. Pond, Feb. 17, 1957
Thomas F. Sullivan, Aug. 27, 1957
Charles W. Sherman, Jan. 19, 1958
Arthur A. Shurcliff, Nov. 12, 1957
George N. Watson, Sept. 14, 1957

Meetings of the Society

March 20, 1957. Address by the retiring President, John G. W. Thomas. "The Proprietors of the Locks and Canals on Merrimack River".

April 15, 1957. Joint Meeting with Massachusetts Section, American Society of Civil Engineers. Panel discussion "Why Two Engineering Societies in Boston". John B. Wilbur, Moderator. Panel members E. B. Cobb, A. Haertlein, J. G. W. Thomas and E. Ireland.

May 15, 1957. "Hurricane Protection in New England", Peter J. A. Scott and John B. McAleer, Project Engineers, N. E. Div. Corps of Engineers, Boston, Mass.

June 3, 1957. Special meeting regarding membership dues.

September 25, 1957. "Oahe Dam on the Missouri River—The Engineering Problems of a Shale Foundation". Mr. J. O. Ackerman, Chief Engineer, Div. Omaha Dist., Corps of Engineers, Omaha, Nebraska.

October 23, 1957. Joint Meeting with the Massachusetts Section, American Society of Civil Engineers. Student Night. "Use and Abuse of Consultants in

Foundation and Earthwork Engineering". Dr. Karl Terzaghi, Professor Emeritus, Practice of Civil Engineering, Harvard University.

November 20, 1957. "Philosophy of Pile Foundations". Dr. Philip C. Rutledge, Partner, Moran, Proctor, Mueser and Rutledge, New York.

December 18, 1957. "A Consideration of New Trends in Reinforced Concrete". Dr. Guilio Pizetti of Italy, visiting Professor at M.I.T.

January 22, 1958. Joint Meeting with the Sanitary and Hydraulics Section B.S.C.E. "A Symposium on Water Resource Development". Professor Arthur A. Maass, Assoc. Prof. of Government, Graduate School of Public Administration, Harvard Univ., and Mr. James S. King, Civil Engineer, Corps of Engineers, North Central Div., U. S. Army.

February 19, 1958. Joint Meeting with Structural Section. Forum Discussion of Foundation Section of Proposed Boston Building Code. H. A. Mohr, Moderator.

Attendance at Meetings

DATE	PLACE	MEETING	DINNER
March 20, 1957	Hotel Vendome	38	133
April 15, 1957	Faculty Club, M.I.T.	87	71
May 15, 1957	Hotel Lenox	30	—
June 3, 1957	Society Rooms	41**	
Sept. 25, 1957	United Community Services Building	76	*
Oct. 23, 1957	Northeastern University	436	366
Nov. 20, 1957	United Community Services Building	105	*
Dec. 18, 1957	United Community Services Building	66	*
Jan. 22, 1958	United Community Services Building	133	84
February 19, 1958	United Community Services Building	97	58

*Collation served after meeting.
**Not included for average attendance.

Sections

Twenty-five meetings were held by the Sections of the Society during the year. These meetings of the Sections offering opportunity for more detailed discussions continue to demonstrate their value to their members and to the Society. A wide variety of subjects were presented and large attendance at these meetings has continued. The Annual Reports of the various Sections will be presented at the Annual Meeting and will be published.

*Funds of the Society**

Permanent Fund. The Permanent Fund of the Society has a present value of $60,141.66. The Board of Government authorized the use of as much as neces-

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

sary of the current income of this fund in payment of current expenses. By vote of the Society (as prescribed by the By-Laws) at the January 22, 1958 and February 19, 1958 meetings, the Board of Government was authorized to transfer an amount not to exceed $6000 from the Principal of the Permanent Fund for Current Expenditures. The amount necessary to transfer for Current Expenditures was

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 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; for underwriting meritorious books or publications pertaining to hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to this Society; or establishing a traveling scholarship every third year open to members of the Society for visiting engineering works, a report of which would be presented to the Society.

Edmund K. Turner Fund. In 1916 the Society received 1,105 books from the Library of the late Edmund K. Turner, and a bequest of $1,000, "the income of which is to be used for library purposes". The Board voted to use $50 of the income for the purchase of books for the library. The expenditures from this fund during the year was $42.50.

Alexis H. French Fund. The Alexis H. French Fund, a bequest amounting to $1,000, was received in 1931, from the late Alexis H. French of Brookline, a former Past President of the Society. The income of the fund is "to be devoted to the Library of the Society". The Board voted to use $250 of the available income for the purchase of books for the Library. The expenditure from this fund during the year was $45.40.

Tinkham Memorial Fund. The "Samuel E. Tinkham Fund", established in 1921 at Massachusetts Institute of Technology by the Society, "to assist some worthy student of high standing to continue his studies in Civil Engineers", had a value of $2730.36 on June 30, 1957. Frank S. Koppelman of Newark, New Jersey, a student in Civil Engineering, class of 1959 was awarded this Scholarship of $100 for the year 1957-58.

Desmond FitzGerald Fund. The Desmond Fitz-Gerald Fund established in 1910 as a bequest from the late Desmond FitzGerald, a Past President and Honorary Member of the Society, provided that the income from this fund shall "be used for charitable and educational purposes". The Board voted on April 8, 1957 to appropriate from the income of this fund the sum of $100 to be known as the Boston Society of Civil Engineers Scholarship in Memory of Desmond FitzGerald and be given to a student at Northeastern University. It was VOTED on May 13, 1957 "to adopt the recommendation of the Committee at Northeastern University, namely, a $100 Scholarship to be given to Bruce N. MacIver. Presentation to be made at the Annual Meeting of the Society March 19, 1958.

Clemens Herschel Fund. This fund was established in 1931, by a bequest of $1,000 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 presentation of prizes for papers which have been particularly useful and commendable and worthy of grateful acknowledgment". The Board of Government voted on April 8, 1957 that payment of the Herschel Prize Award and Section Prize Awards be appropriated from the income of this fund. The expenditure made during the year from the income of this fund was $69.60.

Edward W. Howe Fund. This fund, a bequest of $1,000 was received in 1933 from the late Edward W. Hode, 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 was that the fund be kept intact, and that the income be used "for the benefit of the Society or its members". The Board of Government voted on April 8, 1957 "that no appropriation be made from this fund at the present time".

William P. Morse Fund. This fund, a bequest of $2,000 was received in 1949 from the late William P. Morse, a former member of the Society. No restrictions were placed upon the use of this money but the recommendation of the Board of Government was "that the fund be kept intact and that the income be used for the benefit of the Society or its members". Upon recommendation of a Committee appointed by the President, the Board voted on April 5, 1954 to appropriate from the income of this fund the sum of $100 to be known as the Boston Society of Civil Engineers Scholarship in Memory of William P. Morse, and be given to a student at Tufts University. It was VOTED on May 13, 1957 "to adopt the recommendation of the Committee at Tufts University, namely, a $100 Scholarship be given to Robert W. McEvoy.

Prizes

AWARD	RECIPIENT	PAPER
Desmond FitzGerald Award	Howard Simpson	"The New ACI Code—Its Implications and Ramifications".
Clemens Herschel Award	Frank L. Lincoln) Robert J. Basso) Joseph Peraino)	"Rehabilitation of Wharves and Piers—Army Base, South Boston".
	Saul Namyet	"Analog and Digital Computers in Civil Engineering".
Structural Section Award	Harl P. Aldrich, Jr.	"Site Preloading Eliminates Piles for Two Oil Storage Tanks".
Transportation Section Award	Ernest A. Herzog	"A Forward Look in Transportation".
Northeastern University Student Section Award	Alfred J. Schiff	"Examination of Private Water Supplies by the Mass. Dept. of Public Health".

Library

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

Committees

Thte usual special committees dealing with the activities and conduct of the Society were appointed. The membership of these committees is published in the JOURNAL and the reports of these committees will be presented at the Annual Meeting.

In addition to routine business of the Society the Board of Government took action as follows:

May 13, 1957	Voted "to extend felicitations to the New England Water Works Association on the occasion of its 75th Anniversary". Voted "to make 300 reprints of the J. G. W. Thomas Presidential Address available for distribution at A.S.C.E. Hydraulic Conference at M.I.T. in August".
July 29, 1957	Voted "to enter into a lease with the First Realty Company of Boston for approximately 1200 Sq. Ft. on the 6th Floor at 20 Pemberton Square, Boston.
August 23, 1957	Voted "that Chairman William L. Hyland of the Quarters Committee be authorized to sign a 5 year lease for the new quarters at 20 Pemberton Square, and to agree to the terms of sharing with the First Realty Company of Boston the expenses of remodeling the new quarters".
Sept. 23, 1957	Voted "that Joint Legislative Committee continue its efforts toward presentation of a bill before next year's legislature for Mandatory Registration of Engineers and Land Surveyors", and further "that committee determine what other participating organizations will commit themselves financially in joint effort to secure passage of a law in 1958".

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.

ARTHUR CASAGRANDE, *President*

REPORT OF THE TREASURER

Boston, Massachusetts
March 19, 1958

To the Boston Society of Civil Engineers:

Your treasurer has the honor of submitting his report for the fiscal year ending March 1, 1958. The acquisition of the new Society Rooms, 20 Pemberton Square, and the activities in connection with registration of Professional Engineers have greatly increased our financial problems of the past year.

The gross expenditures incurred, by our Registration Committee, during the year was $3,289.53. The Boston Society of Civil Engineers received contributions from other Professional Societies to the sum of $1,050.00. Therefore, the net expenditures to our Society was $2,239.53.

The new quarters expenditures; including moving, carpentry work for library, renovations to new quarters, and sundry labor, was in the amount of $3,597.91.

The old quarters lease expires May 30, 1958 and an adjusted or negotiated agreement was made with Tremont Temple. The balance due Tremont Temple under the terms of our lease was $1,750.00. This was abated by an amount of $875.00, and the balance of $875.00 was paid to the Temple February 25, 1958. With this transaction, the Boston Society of Civil Engineers has terminated its association with Tremont Temple which began in 1896.

This year it was necessary to transfer $7,539.54 from the Permanent Fund. The net income to the Permanent Fund was $3,559.68, therefore, a sum of $3,979.86 was transferred from the principal of the Permanent Fund. It will be noted that the three above unusual expenditures, which total $6,712.44 exceeds the amount transferred from the principal of the Permanent Fund.

The Boston Safe Deposit and Trust Company is our investment counsel and acts as our agent, collecting interest and dividends for the Society. The Boston Safe Deposit and Trust Company is custodian of our securities and once a year, dated the close of business as of March 1st, the treasurer receives from the Boston Safe Deposit and Trust Company a certified statement of bonds, stocks, interest, and dividends held by the Bank in the name of the Society.

Table I, below, compares the book value as of March 1, 1958 with the market value as of March 1, 1958 of our bonds, stocks, Co-operative Bank deposit, and monies available for investment.

TABLE I

	BOOK VALUE 3/1/58	MARKET VALUE 3/1/58
Bonds	$ 51,907.25	$ 48,956.90
Stocks	51,432.25	106,907.46
Co-operative Bank	5,003.89	5,003.89
Available for Investment	1,212.35	1,212.35
Total	$109,555.74	$162,080.60

Table II compares the book value of March 1, 1958 with the market value as of March 1, 1958 of our Funds.

TABLE II

FUNDS	BOOK VALUE 3/1/58	MARKET VALUE 3/1/58
Permanent	$ 60,141.66	$ 88,975.69
John R. Freeman	34,736.58	51,390.51
Edmund K. Turner	1,239.77	1,834.16
Desmond FitzGerald	2,424.40	3,586.74
Alexis H. French	1,242.20	1,837.75
Clemens Herschel	1,145.80	1,695.14
Edward W. Howe	1,167.04	1,726.56
William P. Morse	2,403.19	3,555.36
Surveying Lectures	421.68	623.85
Structural Lectures	304.54	450.55
Publications	4,328.88	6,404.29
	$109,555.74	$162,080.60

The income for the fiscal year was $6,498.48 for the above named funds. This represents an approximate interest rate of 5.93% based upon the book value and an approximate interest rate of 4.01% based upon the market value as of March 1, 1958.

The financial standing of the Society is summarized in four tables, namely:

Table III Distribution of Funds—Receipts and Expenditures
Table IV Record of Investments—Bonds
Table V Record of Investments—Stocks
Table VI Record of Investments—Co-operative Bank

CHARLES O. BAIRD, JR., *Treasurer*

TABLE III—REPORT OF TREASURER MARCH 1, 1958

	Distribution of Funds			Receipts and Expenditures				
	1 Book Value March 1, 1957	Interest and Dividends Cash 2	Interest and Dividends Credit 3	Net Profit or Loss at Sale or Maturity + 4	Net Profit or Loss at Sale or Maturity — 5	Transfer of Funds + 6 Purchased	Transfer of Funds Sold — 7	Book Value March 1, 1958 8
Bonds	$51,907.25	$1,691.95						$51,907.25
Co-op. Bank	4,845.16		$158.73					5,003.89
Stocks	51,465.51	4,647.80				$51.80	$85.06	51,432.25
Available for Investment	2,888.24						1,675.89	1,212.35
	$111,106.16	$6,339.75	$158.73			$51.80	$1,760.95	$109,555.74

Columns 1 + 3 + 6 — 7 = 8

TABLE III—Continued

Funds	Book Value March 1, 1957	Allocation of Income—Profit and Loss Income Col. 2 & 3	Net Profit 4 & 5	Received	Expended	Book Value March 1, 1958
Permanent	$63,551.52	$3,886.03		$570.00	$7,865.89*	$60,141.66
John R. Freeman	32,582.49	1,992.34		329.08	167.33	34,736.58
Edmund K. Turner	1,214.25	74.25			48.73	1,239.77
Desmond FitzGerald	2,392.87	146.32			114.79	2,424.40
Alexis H. French	1,219.31	74.55			51.66	1,242.20
Clemens Herschel	1,151.55	70.42			76.17	1,145.80
Edward W. Howe	1,105.14	67.58			5.68	1,167.04
William P. Morse	2,370.41	144.95			112.17	2,403.19
Publications	3,835.79			545.84	52.75	4,328.88
Surveying Lectures	399.31	24.42			2.05	421.68
Sanitary Lectures	995.12			292.00	1,287.12	0.00
Structural Lectures	288.40	17.62			1.48	304.54
	$111,106.16	$6,498.48		$1,736.92	$9,785.82	$109,555.74
Current	1,500.00	3,559.68**		22,514.17	26,073.85	1,500.00
Totals	$112,606.16	$10,058.16		$24,251.09	$35,859.67	$111,055.74

Secretary's change fund of $30.00 should be added to show total cash.

Cash Balance March 1, 1958			
Investment Fund	$1,212.35	$7,539.54*	Transferred from Permanent Fund
Current Fund	1,500.00	3,559.68**	Transferred from Income of Permanent Fund
Total Cash	$2,712.35	$3,979.86	Transferred from Principal of Permanent Fund

TABLE IV—RECORD OF INVESTMENTS—BONDS
March 1, 1957 to March 1, 1958

	Date of Maturity or Classification	Fixer or Current Interest Rate	Interest Received	Par Value	Book Value March 1, 1958	Market Value March 1, 1958
U. S. Savings Bond Series G	May 1, 1958	2½%	$100.00	$4,000.00	$4,000.00	$4,000.00
U. S. Savings Bond Series G	May 1, 1960	2½%	25.00	1,000.00	1,000.00	1,000.00
U. S. of America Savings Bond Series K.	Aug. 1, 1966	2.76%	193.20	7,000.00	7,000.00	7,000.00
Columbia Gas System Inc., Deb., Series D	July 1, 1978	3.50%	70.00	2,000.00	2,066.17	1,940.00
Consumers Power Co. 1st Mtge.	Sept. 1, 1975	2⅞%	86.25	3,000.00	3,140.35	2,685.00
Florida Power Co. 1st Mtge.	July 1, 1984	3.125%	31.25	1,000.00	1,017.50	867.50
Florida Power Co. 1st Mtge.	July 1, 1986	3.875%	193.75	5,000.00	5,037.59	5,031.50
General Motors Acceptance Corp. Deb.	Sept. 1, 1975	3.625%	181.25	5,000.00	5,101.80	4,787.50
Georgia Power Co. 1st Mtge.	Dec. 1, 1977	3.375%	168.75	5,000.00	5,162.50	4,700.00
Province of Ontario	Sept. 1, 1972	3¼%	97.50	3,000.00	2,936.25	2,842.50
Public Service Electric and Gas Co.	June 1, 1979	2⅞%	115.00	4,000.00	4,097.50	3,510.00
Scott Paper Co. Conv. Deb.	Mar. 1, 1971	3.00%	30.00	1,000.00	1,123.79	991.30
So. Pacific 1st Series A, Oregon Lines	Mar. 1, 1977	4.50%	180.00	4,000.00	4,191.30	3,775.20
Superior Oil Co. Deb. S.F.	July 1, 1981	3.75%	150.00	4,000.00	4,000.00	3,945.20
Tidewater Oil Co. S.F. Deb.	Apr. 1, 1986	3.50%	70.00	2,000.00	2,032.50	1,881.20
			$1,691.95	$51,000.00	$51,907.25	$48,956.90

TABLE V—RECORD OF INVESTMENTS—STOCKS
March 1, 1957 to March 1, 1958

Stocks	Classificaton	Number of Shares	Dividend Received	Book Value March 1, 1958	Market Value March 1, 1958
American Telephone and Telegraph Co.	Common	69	$621.00	$7,923.06	$11,919.75
Consolidated Edison Co. of New York, Inc.	Common	50	120.00	2,538.56	2,450.00
Continental Insurance Co.	Common	136	272.00	3,483.73	6,902.00
General Electric Co. of New York	Common	150	300.00	2,341.47	9,187.50
Hartford Fire Insurance	Common	26	78.00	1,472.75	4,199.99
Jewel Tea Co., Inc.	Common	30	60.00	1,442.90	1,785.00
National Dairy Products Corp.	Common	100	180.00	1,154.74	4,063.00
New England Electric Co.	Common	198	198.00	3,095.00	3,193.74
Pacific Gas and Electric Co.	Preferred	100	150.00	2,704.89	3,250.00
Pacific Gas and Electric Co.	Common	100	240.00	3,365.34	5,163.00
Radio Corporation of America	Preferred	20	70.00	1,720.75	1,460.00
Scott Paper Company	Common	75	150.00	4,860.00	4,575.00
Southern California Edison Co. Ltd.	Preferred	40	96.00	1,140.24	2,080.00
Southern California Edison Co.	Common	45	108.00	1,350.65	2,334.60
Standard Oil of New Jersey	Common	324	729.00	3,260.66	15,918.12
Southern Railway Co.	Preferred	75	75.00	1,136.80	1,275.00
Texas Company	Common	213	488.80	3,008.12	12,513.75
Union Carbide Corp.	Common	100	360.00	2,958.44	8,863.00
Union Pacific Railroad	Common	220	352.00	2,473.29	5,775.00
Total		2071	$4,647.80	$51,432.25	$106,907.46

TABLE VI—RECORD OF INVESTMENTS—CO-OPERATIVE BANK

Co-operative Bank	Classification	Dividend Received	Book Value March 1, 1958	Market Value March 1, 1958
Suffolk Co-operative Federal Savings and Loan Association Account No. S-631	Savings Account	$158.73	$5,003.89	$5,003.89

REPORT OF THE SECRETARY

Boston, Mass., March 19, 1958

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, 1958

Office	Expenditures	Receipts
Secretary, salary & expense	$500.00	
Treasurer's Honorarium	200.00	
Stationery, printing & postage	567.97	
Incidentals & Petty Cash	165.94	
Insurance & Treasurer's Bond	24.01	
Quarters, Rent, Tel.	4,704.07	$820.00
Office Secretary	4,069.10	
Social Security	116.20	
Meetings		
Rent of Halls, etc.	275.00	
Stationery, printing & postage	42.00	
Hospitality Committee	1,429.01	1,176.20
Reporting & Stereopticon	35.00	
Annual Meeting, March, 1957	689.35	524.00
Sections		
Sanitary Section	18.69	
Structural Section	52.42	
Transportation Section	24.31	
Hydraulics Section	13.65	
Construction Section	18.00	
Surveying & Mapping Section	11.53	
Journal		
Editor's salary & postage	518.81	
Printing & Postage	3,942.58	
Advertisements	38.40	2,094.70
Sale of Journals & Reprints		1,468.52
Library		
Periodicals	52.68	
Binding	249.75	
Forward	$17,758.47	$6,083.42

	Expenditures	Receipts
Brought forward	$17,758.47	$6,083.42
Miscellaneous		
Badges	56.59	15.00
Bank Charges	6.07	
Miscellaneous	7,170.79	1,145.64
Engineering Societies Dues and charge for Journal Space	953.63	
Public Relations Committee	35.25	
Flood Committee	90.05	
Membership Committee	3.00	
Dues from B.S.C.E. Members		11,290.25
Trans. Income Perm. Fund		3,559.68
Trans. Principal		3,979.86
	$26,073.85	$26,073.85

Entrance Fees to Permanent Fund $570.00

53 New Members; 1 Associate Member, 25 New Juniors; 3 New Students, 6 Juniors transferred to Member.

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 23 (Petty Cash) to be used as a fixed fund or cash on hand. $100 withholding tax and $41.84 Social Security which is payable to the Collector of Internal Revenue in April, 1958 is not included in the above tabulation.

ROBERT W. MOIR, *Secretary*

REPORT OF THE AUDITING COMMITTEE

Boston, Mass., March 19, 1958

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 we have compared the bank statement of securities held by the Boston Safe Deposit and Trust Company with the enumeration submitted by the Treasurer.

We have found them to be in order and to account accurately for the Society's funds

GEORGE G. BOGREN
KENNETH F. KNOWLTON

REPORT OF THE EDITOR

March 19, 1958

To the Board of Government
Boston Society of Civil Engineers:

The JOURNAL was issued quarterly, in the months of April, July and October, 1957 and January, 1958 as authorized by the Board of Government on December 20, 1935.

During the year there have been published 12 papers presented at meetings of the Society and Sections

The four issues of the JOURNAL contained 302 pages of papers and proceedings, 6 pages of Index and 49 pages of advertising, a total of 357 pages. An average of 1590 copies per issue were printed.

The cost of printing the JOURNAL was as follows:

Expenditures	
Composition and printing	$2,964.39
Cuts	439.76
Wrapping, mailing & postage	266.85
Editor	502.81
Advertising Solicitor	38.40
Copyright	16.00
Envelopes	233.30
Reprints	38.28
	$4,499.79
Receipts	
Receipts from sale of JOURNAL and reprints	$1,468.52
Receipts from Advertising	2,094.70
	$3,563.22
Net cost of JOURNAL to be paid from Current Fund	$936.57

CHARLES E. KNOX, *Editor*

REPORT OF THE LIBRARY COMMITTEE

Boston, Mass., March 19, 1958

To the Boston Society of Civil Engineers:

On behalf of the Library Committee I submit this report for the year 1957-58.

More use has been made of the library recently as apparently members are becoming better acquainted with the new location at 20 Pemberton Square. One hundred forty five books were loaned during the year which is 100 less than last year. No money was collected in fines.

The following expenditures were made during the year:

Subscriptions to Periodicals	$52.68
New Books	87.50
Binding	249.75

The following books were purchased for the library:

American Civil Engineering Practice, Vol. III, Robert W. Abbett.
C.R.S.I. Handbook, Concrete Reinforcing Steel Institute.
Earth Pressure & Retaining Walls, Whitney, Clark, Huntington.
Management for Engineers, McGraw-Hill.
Mathematics for Science and Engineering, P. L. Alger.
Aspects of River Pollution, L. Klein.
Algal Culture, J. S. Burlem.
The Design and Construction of Engineering Foundation, F. D. C. Henry
Structures, Pier Luigi Nervi.

In addition to the above two books were donated to the library, Mr. Ralph S. Archibald gave a copy of "Elementary Mechanics of Fluids", by Hunter Rouse, and Prof. Gordon M. Fair gave a copy of "Elements of Water Supply and Waste Water Disposal", which was written by Prof. Fair and Prof. Geyer.

The Library Committee wishes to recommend that a copy of "Proceedings of the Fourth International Conference on Soil Mechanics and Foundation Engineering" be purchased if funds are available next year. We also recommend that a library maintenance fund be established. The fund would be used to remove all books from the shelves for a thorough cleaning once a year.

CLIFFORD S. MANSFIELD, *Chairman*

REPORT OF THE HOSPITALITY COMMITTEE

Boston, Mass., March 8, 1958

To the Boston Society of Civil Engineers:

The Hospitality Committee submits the following report for the year 1957-58:

The Annual Dinner, a joint meeting with the American Society of Civil Engineers, a Student Night meeting, and six regular meetings of the Society were held during the past year.

Catered dinners were served prior to two of the regular meetings at the Adams Room of the United Community Services Building. The attendance at each of these dinner meetings was substantially greater than at similar occasions last year. Collations were served by this committee following three of the regular meetings.

The average attendance of members and guests for all nine meetings or dinners (using the larger attendance figure) was 129. Attendance at regular meetings of the Society showed a small increase over the previous year with an average of 84,

SUMMARY OF MEETINGS AND ATTENDANCE

DATE	PLACE	ATTENDANCE MEETING	DINNER
Mar. 20, 1957	Hotel Vendome	38	133
April 15, 1957	Faculty Club, M.I.T.	87	71
May 15, 1957	Hotel Lenox	30	—
Sept. 25, 1957	United Community Services Building	76	*
Oct. 23, 1957	Northeastern University	436	369
Nov. 20, 1957	United Community Services Building	105	*
Dec. 18, 1957	United Community Services Building	66	*
Jan. 20, 1958	United Community Services Building	133	84
Feb. 19, 1958	United Community Services Building	97	58

*Collation served after meeting.

FRANK T. SMITH, JR., *Chairman*

REPORT OF THE MEMBERSHIP CENTRAL COMMITTEE

Boston, Mass., March 19, 1958

To the Boston Society of Civil Engineers:

During the past year, our committee is glad to report, membership in the Boston Society of Civil Engineers reached an all time high of 1,083.

Two meetings of the committee were held during the year where general methods of adding to the membership were discussed. As a part of our activity the Committee mailed a letter, together with application blank and descriptive literature to all non-members who attended the previous year's Lecture series of the Sanitary Section. There were also many personal and mail contacts made with potential members.

The present status of Society membership is as follows:

Elected to Grade of Member during year	53
Elected to Grade of Junior during year	25
Elected to Grade of Student during year	3
Total Society Membership as of this date	1,080
Plus Applications on hand pending action	18

In order to maintain our present large membership and growth individual efforts of all members is essential. Descriptive literature is still available from a previous printing, but should be reprinted soon in the light of dues changes, etc. Any members desiring copies of same for distribution should contact members of this committee.

RALPH S. ARCHIBALD, *Chairman*

REPORT OF ADVERTISING COMMITTEE

Boston, Mass., March 10, 1958

To the Boston Society of Civil Engineers:

During the past year no meetings of the Advertising Committee have been held. In accordance with procedure followed during the year 1956, Mrs. Virginia Boudia has continued to act as advertising solicitor for the JOURNAL. The committee feels that this work has been handled in a satisfactory manner and recommends that the same arrangements be made for the coming year.

During the past year $2,094.70 was collected from advertisers from which commissions totalling $38.40 were paid to the solicitor.

The following advertising has been carried on in the JOURNAL during the year:

	April	July	October	January (1958)
Professional cards	37	37	37	36
½ page	1	1	1	1
¼ page	23	22	22	22
Full page	1	1	1	2
Total pages of Advertising	12	12	12	13

The Committee wishes to express its appreciation to all those who have supported the JOURNAL through advertising.

RALPH M. SOULE, *Chairman*

REPORT OF THE JOHN R. FREEMAN FUND COMMITTEE

Boston, Mass., March 10, 1958

To the Boston Society of Civil Engineers:

Mr. Lawrence C. Neale, the recipient of the scholarship for travel in Europe during 1955, completed his report, which will shortly be on file at the Society Rooms. A summary was published in the October number of the JOURNAL, but the committee decided not to publish the report in full.

The fund contributed this year towards the expenses of the Seminar on Water Treatment and Disposal a total of $670.92. Except for the publication of the report of the Committee on Floods, which is expected to come out this year, the Committee has as yet no definite plans for any scholarships or other projects this year.

HOWARD M. TURNER, *Chairman*

REPORT OF JOINT LEGISLATIVE COMMITTEE

Boston, Mass., March 12, 1958

To the Boston Society of Civil Engineers:

The principal activity of the Joint Legislative Committee during the past year was the attempt to secure passage in the General Court of a bill providing for mandatory registration of professional engineers and land surveyors.

The bill was enacted by both the House and Senate, but was returned to the Legislature by the Governor with a request for certain amendments. It was deadlocked in committee, as the session ended, and the measure was killed.

The proposed act has been resubmitted to this year's legislative session and is now known as Senate 500. The bill has been printed and copies are available at the State House. A public hearing was held on February 24, 1958, at the State House before Committee on State Administration and has not been reported out at this writing.

A new committee has been formed to press for passage with representatives from twelve engineering societies. The new group is sponsored by Engineering Societies of New England, assisted by Massachusetts Society of Professional Engineers. Mr. Frank L. Heaney is chairman of the new committee and represents the Massachusetts Section of American Society of Civil Engineers. Boston Society of Civil Engineers is represented by Mr. Edward Wright.

Mr. Henry D. Winslow resigned as legislative agent on February 13, 1958, due to pressure of other business. Mr. Michael J. Neville has been retained to take his place. Your committee wishes to express its appreciation of the fine services rendered by Mr. Winslow.

A bill providing for mandatory registration of architects was passed during the last session of the Legislature. The Joint Committee held several meetings with the architects' legislative committee, and amendments were inserted in both the architects' and engineers' bills to remove conflict between the interests of the two professions.

Bills before the current session of the General Court, which are of concern to civil engineers, are as follows:

House 1978. Relating to requirement that plans filed in Registry of Deeds, or in Land Court, bear the seal of a registered land surveyor. This is sponsored by Massachusetts Association of Land Surveyors and Civil Engineers.

Senate 492. Relating to plans, specifications, and bids on public buildings sponsored by Associated Subcontractors of Massachusetts.

Senate 500. Relating to mandatory registration of engineers and land surveyors sponsored by Senator Graham and a group representing engineering and surveying societies.

Relating to contracts, bids, and specifications are:

House 1094, 1096, 1449, 1500, 1501, 1502, 1754, and 1759.

Some of these bills are sponsored by Massachusetts Federation of Labor, some by Associated General Contractors of Massachusetts, and some by Associated Subcontractors of Massachusetts, and some by Individuals.

EDWARD WRIGHT
JAMES F. BRITTAIN
FRANK L. HEANEY, *Chairman*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION

March 3, 1958

To the Sanitary Section
Boston Society of Civil Engineers :

Five meetings of the Sanitary Section were held during the year as follows:
1. March 6, 1957. Annual Meeting. The following officers and members of the Executive Committee were elected:

John F. Flaherty	Chairman
Clair N. Sawyer	Vice Chairman
Joseph C. Knox	Clerk
Harold A. Thomas, Jr.	Member
George M. Reece	Member
James L. Dallas	Member

A paper on "Disposal of Atomic Power Plant Wastes" was presented by Dr. Conrad P. Straub. Fifty-two members and guests attended the meeting, and twenty attended the informal dinner at Patten's Restaurant.

2. June 6, 1957. Annual Outing. The Sanitary Section, at the invitation of the New England Federation of Sewage and Industrial Wastes Association, joined them at their Spring meeting and inspection trip at Newport, Rhode Island.

Twenty members of the section attended the dinner at the Viking Hotel and the inspection of the Newport sewage disposal works.

3. October 2, 1957. Professor Werner Stumm presented a paper on "Ozone as a Disinfectant for Water and Sewage."

Twenty-eight members and guests attended the meeting, and fifteen attended the informal dinner at Patten's Restaurant.

4. December 4, 1957. An illustarted paper on "Air Pollution Control Engineering" was presented by Dr. Leslie Silverman.

Forty-five members and guests attended the meeting and twelve attended the dinner at Patten's Restaurant.

A nominating committee comprising Edward W. Moore, Chairman, Ariel A. Thomas and Darrell A. Root was elected and directed to present a slate of officers and members of the Executive Committee at the Annual Meeting to be held March 5, 1958.

5. January 22, 1958. Joint meeting with the parent society and the Hydraulic Section.

A symposium on "Water Resource Developments" was presented by Prof. Arthur Maass and James S. King. Mr. Sterling who was scheduled to speak was unable to attend due to illness.

Onê hundred anid sixty members and guests attended the meeting and eighty-four attended the dinner in the Adams Room at 14 Somerset Street.

Total attendance for the five meetings was 305 and the average attendance per meeting was 56.

Five meetings of the Executive Committee were held during the year.

The papers prepared for two of these meetings were presented to the Society for publication.

Respectfully submitted,

JOSEPH C. KNOX, *Clerk*

cc: Robert W. Moir (2)
John F. Flaherty
Clair N. Sawyer

REPORT OF THE EXECUTIVE COMMITTEE OF THE STRUCTURAL SECTION

Boston, Mass., March 13, 1958

To the Structural Section
Boston Society of Civil Engineers:

Seven meetings of the Structural Section were held during the year as follows:

April 10, 1957.—Commander E. R. Foster of the Civil Engineer Corps; United States Navy, spoke on the Construction of Texas Tower No. 2. Attendance—35.

October 9, 1957.—J. Roger Hayden of the Dresser-Ideco Company spoke on the Erection of the WBZ Television Broadcasting Tower in Needham. Attendance—34.

November 13, 1957.—Mr. T. R. Higgins, Director of Engineering and Research, American Institute of Steel Construction, gave a talk on "Plastic Design in Steel—A Progress Report". Attendance—37.

December 11, 1957.—Mr. William F. Swiger of the Stone & Webster Engineering Corp. gave an illustrated talk on "Structures for Offshore Drilling". Attendance—32.

January 8, 1958.—Joint Meeting with Construction Section. Mr. A. S. Marvin, Chief Engineer, American Bridge Division,. U. S. Steel Corp., talked on "Effect of Design on Cost of Fabricated Structural Steel". Attendance—87.

February 12, 1958.—Mr. E. C. Keane of Fay, Spofford & Thorndike, and Mr. Eric Reeves of Charles A. Maguire Associates, spoke on the Design of Tunnel Section of the Boston Central Artery. Attendance—72.

February 19, 1958.—Joint Meeting with the Main Society. Mr. H. A. Mohr was Moderator of a forum discussion on "Revision of Part 29, Foundations, of the Boston Building Code." Attendance—97.

March 12, 1958.—Dr. Lauritz Gjerrum, Visiting Professor at Massachusetts Institute of Technology, spoke on the "Construction of Tunnels in Soft Clay". Attendance—52.

The total attendance for the year was 446; average attendance 57.

William A. Henderson, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE HYDRAULICS SECTION

Boston, Mass., February 24, 1958

To the Hydraulics Section
Boston Society of Civil Engineers:

The following meetings were held during the past year:

May 11, 1957.—Professor Leslie J. Hooper and Lawrence C. Neale of the Alden Hydraulic Laboratory of Worcester Polytechnic Institute conducted an inspection and demonstration of the facilities and tests under way at the Laboratory. Attendance—35.

November 6, 1957.—Mr. Robert S. Kleinschmidt, of the Research Staff of Harvard University, spoke on the subject "Design of New Harvard Hydraulic Laboratory for Instruction and Research". The meeting was held at the new Society Rooms. Attendance—21.

January 22, 1958.—Joint Meeting with Main Society and Sanitary Section, at United Community Services Building. Symposium on Water Resource Development. Professor Arthur A. Maass, Graduate School of Public Administration, Harvard University, and head of the Harvard Water Resources Program, spoke on new techniques that will permit the use of high speed computers in the planning of multi-purpose reservoir systems. Mr. James S. King, Civil Engineer, North Central Division, Corps of Engineers, spoke on the functions of upstream and downstream dams in multi-purpose river development. Attendance—133.

February 5, 1958.—Professor Lawrence C. Neale, Assistant Professor of Hydraulics, Worcester Polytechnic Institute, spoke on the subject "Use of River Models in Cooling Water Studies at the Alden Laboratory". Officers for 1958 were elected. The meeting was held at the Society Rooms. Attendance—35.

The total attendance for the year was 224; the average 56.

Lee M. G. Wolman, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SURVEYING AND MAPPING SECTION

Boston, Mass., January 16, 1958

To the Surveying and Mapping Section,
Boston Society of Civil Engineers:

The following meetings of the Surveying and Mapping Section were held during the past year:

April 10, 1957.—Commander E. R. Foster, U. S. N., spoke and a film was shown on "The Story of the Erection of Texas Tower No. 2 at Georges Bank". This was a joint meeting with the Structural Section. Attendance—24.

October 16, 1957.—Topic "Unusual Problems in Surveying and their Solutions". Speakers—Mr. Herman Shea, Mr. Winfield Scofield, Mr. Gordon Ainsworth. Attendance—30.

January 15, 1958.—Mr. Robert Thurrell, Field Engineer, Tellurometer Electronic Distance Measuring System, gave a very interesting talk on these instruments. Attendance—28.

Total Attendance—82; Average Attendance—27.

NELSON GAY, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE TRANSPORTATION SECTION

Boston, Mass., February 27, 1958

To the Transportation Section
Boston Society of Civil Engineers:

The Transportation Section of the B.S.C.E. held three meetings during the 1957-58 season as follows:

April 24, 1957.—H. Gordon Gray, Deputy Chief Engineer for the Federal Interstate Program of Massachusetts Department of Public Works, spoke on "What the New Federal Highway Bill Means to Massachusetts". Attendance—40.

September 18, 1957.—Ernest A. Herzog of Alonzo B. Reed Company of Boston presented a talk on mass transportation methods, especially monorail systems. His subject was "A Forward Look in Transportation". Attendance—35.

February 26, 1958.—Annual Meeting of the Section and election of officers. A slate of officers for the Transportation Section of the B.S.C.E. for year 1958-59 was presented by the nominating committee. The slate was voted in as presented, resulting in the election of the following:

Chairman	Leo F. DeMarsh
V-Chairman	Marcello J. Guarino
Clerk	Robert A. Snober
Executive Committee	Joseph D. Guertin
	William A. Fisher
	James W. Haley

The speaker of this meeting was P. M. Clarke, Street and Highway Lighting Engineer, Westinghouse Company, whose subject was "Street and Highway Lighting". Attendance—12.

It has been suggested in the past that the dates of the February and November meetings be changed. This action is still recommended, because the dates as presently established are generally in conflict with the activities of other groups, and in addition the November meeting comes on the eve of a holiday. For these reasons the two meetings referred to are very poorly attended, and it is believed that a suitable change of dates will remedy the situation.

MARCELLO J. GUARINO, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE CONSTRUCTION COMMITTEE

February 28, 1958

To the Construction Section
Boston Society of Civil Engineers:

The section held four meetings during 1957-1958 season as follows:

March 27, 1957.—Mr. James J. Kenney of the Portland Cement Association spoke on "Prestressed Concrete Bridges". Attendance—42.

May 22, 1957.—Professor Robert J. Hansen of M.I.T. introduced the film "Men, Steel & Earthquakes". Attendance—39.

October 30, 1957.—Professor Albert G. H. Dietz, Professor of Building Engineering at M.I.T., spoke on "The Increasing Use of Component Construction". Attendance—16.

January 8, 1958.—Annual Meeting was held as a Joint Meeting with the Structural Section. Report of the meeting made by the Structural Secion. The newly elected officers of the Construction Section are as follows:

Chairman	William F. Duffy
V-Chairman	William A. Fisher
Clerk	Frank J. Heger
Executive Committee	John D. M. Luttman Johnson
	Robert J. Hansen
	Albert Adelman

ALBERT ADELMAN, *Clerk*

PROFESSIONAL SERVICES

AND

ADVERTISEMENTS

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

Volume 45 JANUARY, 1958 Number 1

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROFESSIONAL SERVICES

INDEX TO ADVERTISERS

COMMITTEES

1958-1959

NOMINATING COMMITTEE

Past Presidents (Members of the Committee)

Emil A. Gramstorff — Chester J. Ginder — Miles N. Clair

John C. Rundlett
George W. Hankinson
Frank L. Heaney
(Term expires March, 1959)

John M. Biggs
Paul A. Dunkerley
William A. Henderson
(Term expires March, 1960)

SPECIAL COMMITTEES

PROGRAM

William L. Hyland, *Chairman, ex-officio*

Edward C. Keane
E. Stanley Johnson
Joseph C. Lawler
Harry L. Kinsel
William F. Ryan
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Francis H. Kingsbury
Robert W. Moir
Clair N. Sawyer
Richard W. Albrecht, Jr.
Leo F. DeMarsh
James W. Daily
George A. McKenna
William F. Duffy

PUBLICATION

Charles E. Knox, *Chairman*

George C. Houser
Robert L. Meserve
Clarence R. Wickerson
Llewellyn L. Cross, Jr.
Clair N. Sawyer
Richard W. Albrecht, Jr.
James W. Daily
George A. McKenna
William F. Duffy
Leo F. DeMarsh

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Leland F. Carter, *Chairman*

Armand L. Phaneuf
Lee M. G. Wolman
Robert S. Kleinschmidt
George A. L. Brown
Joseph H. Lenney
Adin B. Bailey

HOSPITALITY

Whitney K. Stearns, *Chairman*

Joseph E. Heney — Clement Zowadniak

JOHN R. FREEMAN FUND COMMITTEE

Howard M. Turner, *Chairman*

William F. Uhl — Leslie J. Hooper — Thomas R. Camp

DESMOND FITZGERALD AWARD

Emil A. Gramstorff, *Chairman*

E. Sherman Chase — Ernest A. Herzog

SANITARY SECTION AWARD

E. Sherman Chase, *Chairman*

Darrell A. Root — Frank L. Heaney

STRUCTURAL SECTION AWARD

Emil A. Gramstorff, *Chairman*

Myle J. Holley, Jr. — James Adam, Jr.

HYDRAULICS SECTION AWARD

E. Sherman Chase, *Chairman*

Donald R. F. Harleman — Clyde W. Hubbard

SURVEYING & MAPPING SECTION AWARD

Ernest A. Herzog, *Chairman*

C. Roger Pearson — Thomas C. Coleman

CONSTRUCTION SECTION AWARD

Emil A. Gramstorff, *Chairman*

Frederic N. Weaver — Herbert J. Albee

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Lawrence G. Ropes — Irving B. Crosby — Chester J. Ginder

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Horace B. Perry — Benjamin Mills, 3rd

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Edward Wright — James F. Brittain

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