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# BOSTON SOCIETY OF CIVIL ENGINEERS
## OFFICERS, 1962-1963

GEORGE G. BOGREN

*President*

Boston Society of Civil Engineers 1962-63

JOURNAL OF THE

# BOSTON SOCIETY OF CIVIL ENGINEERS

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## OUR PROFESSION AND OUR SOCIETY—THEN AND NOW

PRESIDENTIAL ADDRESS BY JAMES F. BRITTAIN

(Boston Society of Civil Engineers, March 22, 1962.)

AS ONE'S term of office comes to an end, obvious questions to contemplate are "Has the profession of Civil Engineering maintained the status it enjoyed at the time of the founding of our Boston Society of Civil Engineers in 1848"? "Has the Society held its own during recent years"? "Are we living up to the standards our Founding Fathers gave us for an example"? In the case of the latter, I do not want to give the impression that I think we should be slavish to tradition in our rapidly changing times. If you will pardon the presumption, I will first try to interpret the founders' objectives as I visualize them. According to our Constitution adopted June 15, 1910, "the objects of this Society are; the professional improvement of its members, the encouragement of social intercourse among engineers and men of practical sciences, and the advancement of engineering." In addition, I am certain that the organizers also had a keen interest in the development of young men and in the promotion of service to the community.

Civil Engineering as known at the time of the founding of our Society encompassed a pretty broad field including all of the non-military engineering of the day. Our early members supplied power to New England industry by harnessing the numerous streams with which this section of the country was singularly blessed, laid out needed water supplies and designed and built canals for transportation. To accompany these endeavors which would now be known as hydraulic works were all the appurtenant structures and mechanical equipment to make best use of this water. Included were dams and intake works, power units and locks or inclines for raising barges from one level to the next or to by-pass rapids. Waterfront works and protection were also of prime importance. Surveys had to be made, more adequate roads extended to open up the frontiers and later railroads built to supersede most of the canals. These necessitated the development of bridges, many relatively simple, but others quite complicated to allow for the passage of shipping which, by tradition, possessed the right of way. What a challenge, when all engineering was Civil Engineering and the Civil Engineer conceived, planned and carried to completion all of these works.

And how the challenge has changed! As the art of engineering has become more complex, the main Civil Engineering stem has branched out and we have specialization in surveying, bridge engineering, structural engineering, hydraulic engineering with it's own subdivisions into water supply, water power, flood control, water front, hydrologic and hydrographic categories, as well as sanitary, soil mechanics, highway, railway and airport engineering. All of these fields are considered to be within our own present day Civil Engineering and we have the other recognized fields of Mechanical, Electrical, Mining and Chemical Engineering with all their own off-shoots that are no longer recognized as Civil Engineering.

There is much discussion of engineering education and some would have us believe that many of the fundamentals that make a well-rounded civil engineer are no longer necessary. I wonder, if in our present day of specialization we don't need more men with a wide point of view. Some of us have so narrowed our interests that, for example, meetings of our own Main Society with broad subject matter attract smaller attendances than do many section meetings that emphasize some small phase. We find ourselves subdivided into smaller groups that attend only meetings of their own sections. I have been present at meetings of all of the sections this year and seldom saw the same members at the different meetings. I do not want to be misunderstood on this point and have you feel that I do not think section meetings important because I do realize that they serve a great purpose. However, I am convinced that civil engineers should not lower their sights to such an extent that they are not interested in the broader aspects of their profession, with the result that each member attends only the particular meetings dealing with what he considers at the time to be his chosen field. It often happens that, after concentrating on one field for a considerable length of time, a man sees an opportunity to improve his professional status by promotion to a position that requires knowledge or familiarity along other lines than his speciality, and he may find himself disqualified because he has unwittingly set his own ceiling. The unfortunate result is that the Civil Engineer, who was once the overall planner and project engineer has now been forced to the background in a great many instances by others who use him simply for some special knowledge. Frequently men in other fields of engineering and so called "planners" and others are pre-empting the civil engineering function. Why lose our rightful position by default?

I also believe that we have tended toward an interest in things rather than ideas. In other words, we would prefer to hear about monumental structures rather than fundamental ideas and philosophies. I was called to task by one of our members recently because he thought "Trends in Engineering Education" was not of sufficient interest to older members to be a suitable subject for a meeting. And speaking of older members, brings up the subject of their attendance at meetings. It seems as though they are generally conspicuous by their absence. A great many of us look back upon our younger days with pleasant memories of the opportunities we had at meetings to associate with older men we respected. We learned of their experiences and ideas to our great advantage. Of course our Founding Fathers realized the desirability of such an association, for in their time, it was particularly necessary, since technical schools were few in number, and the dissemination of knowledge came about largely through such meetings. I am certain that there is still a great desirability for the exchange of ideas between the generations, and we have the singular opportunity through our Society to bring it about. Why not make an effort not only to insure the attendance of our older members but to urge them in turn to bring young men to the meetings? The young men are to succeed us and we have an unusual opportunity to help them in the process. Perhaps we have been motivated by too much self interest or rugged individualism to encourage them along the way. Or perhaps our profession is becoming too impersonal.

Do we enjoy the same standing in the community as our founders and, if not, what can we do about it to regain our place in the sun? For one thing, let's overcome the sense of inferiority as the more glamorous engineering fields temporarily take the spotlight. Let's take a genuine pride in our profession and our Society and their objectives and accomplishments and emphasize these points to the outside world with our heads up. We should start at the high school level and see to it that the younger generation understands the basic concepts of Civil Engineering and the important function of the Civil Engineer in the community, thereby creating in the students' minds the desire to enroll in the civil engineering courses of our qualified technical schools. Enrollment in our field has fallen off to a large extent due to our own apathy and to self advertising by members of the new fields who are not over endowed with modesty. Why should we "hide our light under a bushel"?

Pioneering that genuinely comes within the scope of civil engineering should be recognized as such instead of becoming a vocation under a new name due to pressagenting of a group that wishes to impress the public with a new patter of its own. Civil Engineering was always fundamental and its ideas can normally be expressed in straightforward terms. It seems as though we are becoming confounded every day by new terminologies and meaningless words uttered by those who want things expressed in terms that no one outside a select few can understand. As the author of "Calculus Made Easy" said years ago "the writers of text books of advanced mathematics seldom take the trouble to show you how easy the easy calculations are. On the contrary, they seem to desire to impress you with their tremendous cleverness by going about it in the most difficult way."

When it comes to advancement of engineering and the professional improvement of its members, or at least, an opportunity for professional improvement of members, I believe the Society has made great strides. Our Journal has a wide circulation and is read at the far corners of the world. This was strikingly brought out at a recent meeting when a speaker from South Africa told us how engineers there looked forward to the receipt of each issue. Our special lecture courses in Hydraulics, Sanitary Engineering, Structures and Surveying have been well attended and have aroused widespread interest due to their high caliber. Our two volumes of reprints of papers from our Journal on the subject of "Soil Mechanics" have been in steady demand ever since their publication and are used as text books at a number of engineering schools across the country. In fact demand for these volumes has been so great that it has been necessary to reproduce the first volume a fifth time. Our special committees that have assembled and published New England Flood data on three occasions, the most recent of which was this last year, have accomplished a monumental task and the service to their fellow engineers, both present and future, is invaluable. This same type of service has been rendered by the special committees that have assembled Boston Boring Data, the latest report of which is now in process. The generosity of a number of members has created funds for use in research and special projects.

Among the objectives mentioned earlier, that of social intercourse should be the easiest to fulfill. With a membership of some eleven hundred we should have a large turnout at any scheduled meeting. However, some of our attendance records are very disappointing and we give the impression that we are not interested in our fellow members or in what they have to say. Of course we must recognize that today with our ease of mobility, we find ourselves in an age of joiners and would like to be in many places at the same time. Consequently we have many conflicting interests which make our meeting attendance suffer. However, I believe that if we are articulate we can maintain our just position in spite of competition. If we talk it up we can start a membership boom and a meeting attendance improvement. Strange as it may seem, countless printed invitations and notices do not bring in members or fill meeting places. What we need is personal interest and contacts. If a prospective member is taken to meetings and introduced personally to the others present he enjoys the warm atmosphere and personal touch and makes up his mind he wants to be a member of the organization. Many members have become lax, and although it should not be necessary, have to be brought to meetings in order to assure their attendance. A hard core of really interested members can correct this situation, I believe. Why don't we all become a part of that hard core?

# ARCTIC CONSTRUCTION

By J. J. Scheuren, Jr.,* *Member*

(Presented at a meeting of the Construction Section, B.S.C.E., held on March 22, 1961.)


## Synopsis

This paper describes construction at Arctic sites in Greenland and Baffin Island. Logistics, personnel, equipment, material, and construction methods are discussed. Comparisons are made with conventional construction procedures in the north temperate zone.


## Introduction

The main reason for interest in Arctic construction during the past two decades has been the requirement for National Defense. Besides the strategic and tactical considerations, there are other reasons for interest in construction in the Arctic (or Antarctic). Sites may be developed for communications, navigational aids for aircraft, surface and subsurface vessels, scheduled and emergency stops for aircraft, weather stations, scientific stations for study of earth and space, and for opening up of natural resources in minerals, oil, and fisheries.

Continuing research into cold weather construction may produce techniques that will extend the construction season in the colder regions of the temperate zone. Actually the basic techniques of construction have not been modified to any great degree in Arctic work.

Construction operations in the Greenland-Baffin Island sector of the Arctic have demonstrated that constructors can use materials, equipment, and methods which are familiar to construction men who have worked in glaciated areas of the temperate zone.

There are three main factors over and above normal problems of cold weather construction, which influence Arctic work. These factors are relative inaccessibility, climate, and terrain.

Each of these affects the problems of personnel, equipment, materials and methods to varying degrees.

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## Inaccessibility

Ice conditions allow short periods for access by surface vessel. Materials, equipment, and personnel for a fifteen month effort may have to be unloaded in several weeks. Equipment may be delivered during one shipping season, be in use during the next shipping season and be idle and not shipped out until the third season. Material storage and warehousing are huge tasks. Relatively extensive camp construction is required. Unless air support can be provided, to evacuate surplus people, excess personnel will be carried over the winter season adding to the problems of extra cost and lowered morale.

Staging of construction is required and facilities for air support should be set up early in the program.

The history of the past ten years of Arctic construction shows the value of staging procedures and air support in expediting the work. (Figure 1)

## History of Staging Procedure

When construction was started at Thule Air Base in 1951 certain valuable staging areas and airstrips were in existence. A gravel strip had been built at Thule after World War II for support of weather stations in the area. An RCAF field was available at Resolute Bay. Airfields and seaports built in World War II were ready for staging and backup at Goose Bay, Frobisher Bay, Sondrestrom, Narsarssuak and Ikateq.

The first landings in connection with construction of Thule Air Base were made in February 1951. Between March 1951 and July 1951 when the first ships of the sea lift arrived, aircraft had delivered the advance construction and engineering personnel and 8,000,000 pounds of cargo. This cargo included supplies, prefabricated huts, bulldozers, trucks, and even a 3/4 C.Y. shovel. The ships brought LST hulks which were beached and used as finger piers. Equipment and material was brought ashore in barges and landing craft. A dock was built and ships were unloaded without need for barges and landing craft.

Most men lived on the ships until the permanent airbase quarters were built. This staging technique saved excessive camp construction.

The sea lift brought in 350,000 tons and 2200 men in 1951, and 100,000 tons in 1952. The air lift brought in 11,000,000 pounds of

FIGURE 1.—MAP OF ARCTIC AREA.

cargo and 3,700 people in 1951, and 6,000,000 pounds of cargo plus 5,200 people in 1952. Over 1,000 flights from the United States to Thule were made in 1951.

Construction at Thule, using both sea lift and air lift has continued into 1961.

In 1952, using Thule as a staging area, the weather station at Nord was built. All personnel equipment and material were transported by air. A small party with several pieces of tracked equipment was landed on the ice on Independence Fjord. They travelled across country to the selected site. Additional supplies and equipment were air dropped; a rough strip was carved out; more material and equipment were landed and the weather station and airstrip were completed.

In 1952 and 1953, Thule was the staging area for two Loran Stations. One of these was in such ice bound location that materials could be landed only during two or three weeks, and preliminary work and camp construction begun. After a month at the site the station was secured for the winter. Construction parties went in from Thule the following year, completed the job, the Coast Guard moved in and the last construction men were evacuated by helicopter to an icebreaker for return to Thule.

In 1953 two stations were built on the Greenland Ice Cap. Equipment and material were flown from Thule and dropped by parachute at the sites. 2,200 tons were dropped at each station with less than three percent loss. Personnel and fragile equipment were transported by ski equipped air planes.

Construction of navigational aids and improved facilities continued over several years at Thule, Sondrestrom and Narsarssuak. To build navigational aid facilities on the island of Simiutak (BW-3) it was necessary to tranship all material from Narsarssuak by barges and tugs for delivery 45 miles down the Fjord. Sand and gravel aggregate was processed at Narsarssuak and shipped to Simiutak.

Since 1955 much construction in the arctic area has been done under low bid fixed price contracts.

Facilities at Frobisher were improved and Dew Line construction made extensive use of the airport. Sites in the Canadian Arctic were supplied by means of sea lift during the short ice free season, by air lift using sea ice and lake ice, by staged construction of roughly scraped out strips and by finally attained finished airfields.

Sondrestrom had become a commercial as well as a military field by 1955. Reconnaissance in 1956 and 1957 from aircraft and surface vessels led to the first stage of the Eastern Extension of the Dew Line across Greenland in 1958.

Beach heads were established by sea lift at Ekalugarssvit (Dye 1) on the west coast and Kulusuk (Dye 4) on the east coast. U. S. Navy under-water demolition teams prepared the beaches. LST's brought in equipment and men. Beaches were improved. More material was brought in by landing craft and barges.

Helicopter support for transport of personnel and critical supplies was provided out of Sondrestrom for the west coast station and out of Ikateq for the east coast station. Personnel and supplies were delivered to Ikateq by 4 engine aircraft from Sondrestrom and Iceland, and shuttled to Kulusuk by helicopter or boats.

By the fall of 1958. (The LST landed in August) the airstrip at Kulusuk was sufficiently completed to take 4 engine aircraft and Ikateq was once more abandoned. Construction was resumed in the spring of 1959 and the two coastal stations were completed in late fall of 1960.

Material and equipment for the two ice caps sites (Dye 2 and Dye 3) were delivered by ship and stock piled at Sondrestom during 1958. Small test camps were set up at the ice cap sites during the summer months and supplied by C-123 ski planes.

In 1959, 4 engine C-130 ski-equipped airplanes hauled material, equipment, and men from Sondrestrom to the ice cap sites. Construction operations were carried on from March to October. 13,000 tons of cargo were airlifted in 1959 and 11,000 tons in 1960. Personnel strength attained a maximum of 100 at each site in 1959 and 200 per site in 1960. Both sites were under construction in 1960 from March until completion in December.

Construction equipment (cranes, bulldozers, compressors, welders, etc.) was returned to Sondrestrom by airlift.

1960 was signalized by the construction of a nuclear-powered installation in tunnels under the Greenland Ice-Cap at Camp Century. Most of the equipment and supplies were delivered by tractor drawn sled trains from Thule. Air support was provided by helicopters and ski-equipped fixed-wing aircraft. Personnel were hauled to the site by either air or surface transport. Equipment and material were hauled to Thule by sea-lift or air-lift and hauled over the road to the icecap approach ramp at Thule takeoff (TUTO). This is another example of staging.

Staging procedures have been vitally necessary to the success of the arctic construction program.

### Air Support

No operation of any size has been accomplished in recent years in the Arctic (or Antarctic) without air support.

Transport in the Arctic needs to be a combination of sea, land and air: dogs, tractors, boats, ships, barges, helicopter, wheeled, amphibian and ski equipped airplanes.

The most efficient use of time is required. No matter what the mission of the facility, air support is a necessary tool in Arctic work. Use of aircraft is invaluable in coping with problems of personnel emergencies, shortages of spare parts, equipment and material. Air support provides operational latitude and reduces standby time of men and equipment.

It is practical for construction and operation that each Arctic site be equipped with the means of handling fixed wing aircraft or at least be provided with helicopter support from a fixed wing aircraft base.

### Climate

There are some benefits bestowed by the arctic climate. From May to September the 24 hour daylight provides good double shift conditions. The light precipitation usually causes little down time for most operations. Even in the winter months advantages are gained by ability to transport materials and equipment over frozen ground, ice, and snow to be ready for the construction season.

Disadvantages are, of course, long periods of below zero temperatures, months of total darkness, high winds and blowing snow. Snowfall varies from as little as one foot to over twelve feet. Even in areas of relatively low snowfall high winds may cause drift problems.

### Methods

Conventional construction techniques are similar to methods used in comparable temperatures in the north temperate zone.

Cold weather concrete placement, curing and protection are the same in Thule as in Northern New England. Duration of the cold weather requires that protection be furnished during most of the year. Because winds up to 150 miles per hour are possible, concrete placement requires stronger enclosures. Heavier insulation of enclosures is required to conserve fuel. Because the weight of the floor slab is usually figured as part of wind reaction design, the constructor may be unable to take advantage of a closed in building to provide protection and will be required to build a separate shelter for floor slab protection before erecting the superstructure.

Because of the duration of cold weather, efforts have been made to extend the construction season for operations not so readily housed and heated as concrete placement.

Cable splicing has been successfully accomplished in heated shelters.

Use of low hydrogen electrodes, a minimum of preheat and heated shelters for operators are valuable in Arctic welding just as in cold weather welding anywhere.

Steel erection, quarry work, panel construction, pipeline and tank work are carried on in cold weather with the aid of protective clothing, wind breaks, warming huts, and shelters.

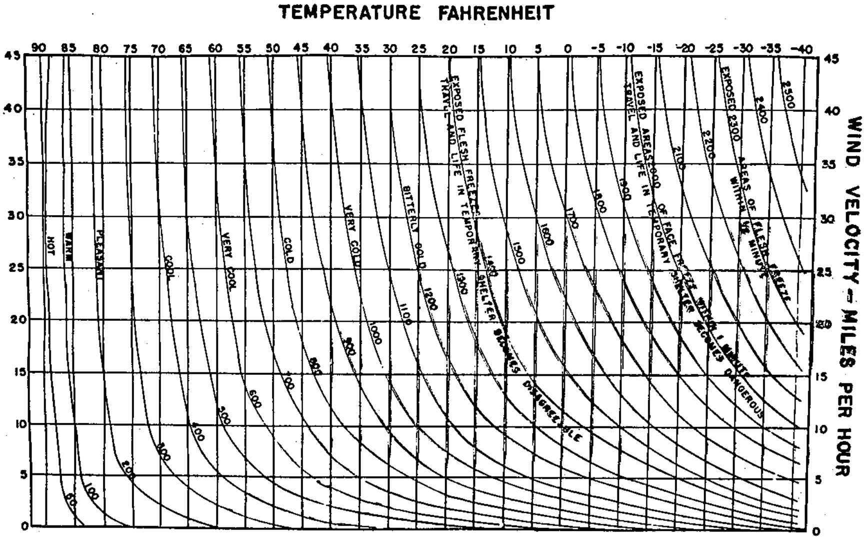
Except for emergency completion of limited areas, paving and grading are usually shut down in the winter. Some minor extensions of the working season have been made by use of heated enclosures, application of heat to subgrades or binder courses by heater-planer (blade grader combined with heater) and in one case by use of aircraft jet blast to thaw and dry base course before asphalt laydown. Satisfactory compaction of one minor building subgrade was obtained by use of dry gravel brought to optimum moisture content by calcium chloride solution.

Because proper compaction cannot be obtained in frozen soils, even those containing minute amount of ice, it is not economical to attempt earth work in freezing weather.

Bituminous concrete is placed in colder weather than usual in the United States. Higher mix and aggregate temperatures, higher asphalt content, shorter pulls of the laydown machine and more rapid application of the breakdown roller are the construction techniques used.

The most feasible winter operations are, of course, those which can be carried on inside buildings already closed in during warmer weather.

It could be estimated that 100% of stateside production is possible in all trades at +50° F and that 0% production is possible at —50° F in between the production is subject to several variables. These variables are wind chill, darkness, phase conditions (white outs, foehn winds, blowing snow), frost, snow and the usual loss of efficiency normal to a seven day work week.




**WIND CHILL NOMOGRAM**

THE "WIND CHILL" FACTOR IS AN INDEX THAT INDICATES THE RATE AT WHICH THE NAKED HUMAN BODY LOSES HEAT WHEN EXPOSED TO VARIOUS TEMPERATURES AND WIND VELOCITIES. THIS CHART SHOWS THAT HIGH WINDS IN AREAS OF LOW TEMPERATURE HAVE A DECIDED EFFECT ON THE RATE AT WHICH THE HUMAN BODY COOLS. NOTE THAT WITH A WIND VELOCITY OF 30 MPH, YOUR FACE WILL FREEZE IN ONE-HALF MINUTE AT -32 DEGREES FAHRENHEIT.

FIGURE 2.

The wind chill effect is described in Figure 2. The variables of production in the Arctic may be stated as follows for outside or partially outside work: Mid-June to Mid-September 100%, Mid-September to Mid-November 60%, Mid-November to Mid-March 20%, Mid-March to Mid-April 40%, and Mid-April to Mid-June 60%.

These estimates may be further qualified by the effect of the long work week in an isolated location. This factor may reduce the maximum production by 20%. Even in July expected production may be only 80% of that obtainable under optimum Stateside conditions.

## Materials

Materials which can be safely stored outside in Northern United States may be stored in like manner in the Arctic. Storage areas should be sited on high ground to minimize snow drifting and provide for spring drainage. Long axes of piles or stacks should be parallel to prevailing wind. Wide spacing is required for access and snow removal. Because of the large space required to shake out the annual supply of materials, it is often necessary to grade considerable storage areas.

## Equipment

The general construction effort can be handled with conventional construction equipment.

It is usual to provide over-snow vehicles for winter transport in some areas and for rescue or emergency travel in all areas. There are several types of tracked or semi-tracked equipment for over-snow travel. Most of these are low ground-pressure tracked vehicles with heated cabs and usually rubber composition tracks. Much improvement can be expected in producing over-snow vehicles with more rugged characteristics.

For winter transport of materials for short distances heavy tracked equipment and sleds may be used. Regular treads are suitable in areas of light snow fall and while wide tracks are commonly used in the deeper snow, they don't hold up as well when used in summer in rocky areas.

All problems affecting equipment in the Arctic will be found in cold weather construction anywhere.

A large supply of spare parts is needed. Wear and tear is heavy under conditions of extreme cold, frozen ground in winter and mud and dust in summer. Equipment should be the heaviest and the most rugged that is transportable. The constructor needs complete well fitted shops for repairs and maintenance.

Motor vehicles should have head bolt or other type of engine heaters which can be plugged into power outlets in "Hot Lines" to obtain heat for warm starting. The usual use is made of motor ether for cold starts and or carbon tetrachloride to dry out moisture and blow snow from ignition systems. Permanent type antifreeze is used all year in most cooling systems. Corrosion can be a problem. Periodic checks should be made of antifreeze quality.

Because of low humidity, there is little condensation in fuel tanks, but the usual good practice of leaving vehicles with well filled tanks should be followed. Various commercial water removal additives are successfully used. Air lines from compressors require alcohol in the oilers or dehumidifiers to prevent freezing in the tools.

Because engines on motor vehicles are idling more than usual, idling speeds should be higher for lubrication and battery charging. All equipment requires well heated cabs.

Attention is given to low ductility transition temperatures for track pads, drill steel, and other metals exposed to shock, impact, and percussion loads. Equipment stored for the winter should be on high ground and well spaced to minimize snow drifting.

## Personnel

The Arctic construction man faces personal problems brought on by climate and inaccessibility. In general, he will be recruited from northern temperate areas. But adaptation to Arctic condition is not necessarily easier for the northerner.

Contractors from Georgia and North Carolina have worked successfully in the Arctic. The Project Manager for the Contractor now at Thule is a native of Arizona. It is probable that much of his stateside work (such as at Garrison Dam) was carried on under as severe conditions of cold and snow as he has experienced in his years of Arctic construction.

Because of round the clock contact and the conditions of climate and remoteness, men should be carefully screened before shipment to the Arctic. The best tests to make of a man are: 1) Do you want him to work for you? and 2) Do you want him to live with you? There does not appear to be any empirical solution. Various testing methods have been used with no conclusive results. However, avoid chronic gripers, avoid men with domestic problems, avoid those who wish to "get away from it all," and be watchful of those who go for glamour or adventure.

Recruitment should be carefully monitored by supervisors who have had Arctic experience and who will be in charge of the men they are screening. The ideal Arctic man is skilled in his trade, healthy, personnally well adjusted, and in short a sound construction hand in any area. A stable and sincere worker in the temperate zone will be a good man in the arctic.

## Living Conditions

A well sited, well built, and well maintained camp is required. Buildings for quarters, messing, recreation, shops, etc. should be sited in accordance with the criteria for design of permanent structures in the area. For snow drift control building will be well spaced, aligned with long axis parallel to prevailing wind, will require few windows, be tight against blowdown, will have no eaves and no re-entrant corners. If they cannot be sited on rock or suitable material provision must be made to protect against subsidence caused by permafrost thaw.

Water supply may be developed from local lakes or ponds. Dams may be built. Snow melting or sea water distillation may be the only means of water supply in some area.

Water may be distributed by heated tank trucks or by heated pipelines. Pipelines or cables should be laid on the ground or well above snow levels to prevent damage by deep snow consolidation (Figure 3).

Sewage may be collected in pits, carried off in wood stave pipes to streams or bays, or collected in tanks and pumped into heated tank trucks for haul away from camp. Septic tanks and leaching fields are not practical in the arctic.

Living conditions should be as good as the contractor can afford and he should carry in his bid estimate ample funds to furnish good food, quarters, sanitary facilities, recreation, mail service, library, laundry, medical care, chaplain services and short wave radio communication.

## Safety

Safety is a continual function and concern of the supervisors. Accidents at a remote site have additional impact on the survivors. Basic principles of safe operation are similar to those anywhere. However bulky clothes, awkward footgear, heavy mittens, icy footing and poor visibility with goggles and parka hoods multiply the chances of falls and collisions.

Careful fitting and adjustment of protective clothing prevents frost-bite. Mandatory use of snow goggles protects against snow blindness and eye damage from cold blowing snow.

There is danger of loss of direction and peril to life in "white outs" caused by blowing snow. Personal safety in violent storms should be assured by safety ropes between buildings, by heated and provisioned shelters at strategic points and by strict monitoring of travel at all times. Movement during bad weather should be rigidly controlled and emergency vehicles should be ready. Men have perished close to camp when they have been unable to find their way to a near by building in a blowing snow storm.

FIGURE 3.—PIPE-LINE DAMAGED BY CONSOLIDATION OF SNOW.

In 1959 a commissary steward at one camp took some sandwiches from the Mess Hall to deliver to a building less than 200 feet away. He walked right by his destination and was headed for a 1,000 foot drop when he had the good fortune to stumble onto a deadlined truck crane. He was able to survive by huddling in the cab until the storm cleared.

Preparation must be made to combat what may seem an odd safety hazard—mosquitos and black flies. But head nets, gloves and insect repellent are requirements for work near the Arctic Circle. Men have required hospital care at Sondrestrom after exposure to the vicious arctic mosquitos.

Dangerous wild animals are few, but many camps, even far out on the Greenland Ice Cap have been visited by polar bears. Sometimes they can be driven off, but often have to be shot. There are authorities who say a polar bear will not attack a man; but at least one Eskimo spent some time only last year lying face down in the hospital at Resolute Bay after being gnawed by a polar bear.

Arctic foxes are dangerous if petted or hand-fed. Their bites can cause tetanus or worse. A most dangerous Arctic animal is a loose sled dog. They should be viewed with suspicion, chained up, tied to a sled, or shot. Many people (mostly aged or children) have been killed by these beasts. A few years ago an Air Force man lost one ear and part of another as a result of an attack by a pack of these dogs. Only his heavy clothing and parka hood saved his life.

It may not be probable that an American, Canadian or Danish construction man would be eating local food. But there have been fatal cases of botulism traced to tainted seal meat and improperly smoked fish. Native food should therefore be mentioned as a safety hazard.

## Terrain

Terrain considerations have the greatest effect on construction in the arctic. The arctic constructor builds on permafrost or on névé Permafrost is perennial frozen ground and névé is perennial snow. Permafrost may extend to depths as great as 2,000 feet. On top of the permafrost is a surface layer which is subjected to annual cycles of freezing and thawing. This layer, called the active layer, varies in thickness from several inches under a mat of vegetation or peat to several feet under desert type pavement or gravelly material with little or no vegetation.

The term permafrost applies to both soil and bedrock, but this discussion will use the word as denoting the frozen mantle of soil from bedrock to the bottom of the active layer.

The active layer is relatively dry and usually contains few free ice inclusions when frozen. The underlying permafrost, particularly in its upper strata, contains varying amounts of ice from minute particles to heavy lenses or layers and often large masses of buried glacial ice. Figure 4 shows a cross section of one such condition encountered. (Active layer is approximately 3½ feet thick).

Both design and construction procedures in permanent country follow a philosophy of fill rather than cut and rill. Stripping of the active layer removes the insulation and causes thawing of the permafrost. In general cuts should be made only in rock, in quarries and borrow pits.

If siting conditions are such that cuts are required, it must be remembered that material obtained from permafrost excavation often has an ice content so high that the quantity of solid fill obtained may be negligible. In one case it was planned to use earth from tank farm grading to build dikes, but the ice content (85–90%) was so high that most of the prospective fill drained away and the dikes had to be built with borrowed material.

Building of roads, either permanent or for construction is complicated in areas of fine grained permafrost with high ice content by inability to balance cuts and fills and because side hill cuts are impractical in such cases.

Because of the ice layer often underlying the muddy bottom of ponds, filling operations may find the fill sliding out into the lake away from shore.

Roads should be raised or follow ridge lines for best snow drift control. Windrows of earth, gravel or snow should not be left on road edges to serve as snow traps. In road construction on steep grades consideration should be given to building a "shoofly" trail and if necessary winching machinery to upper level so as to haul down hill and end dump fill on undisturbed active layer. Ditches should be dug extra depths and partly filled with rock or gravel for protection against thaw and wash. Drainage structures, culverts and bridges should be oversized. Run off calculations based on precipitation and catchment area are not always valid. Look for high water marks on stream banks and slopes. Remember that the amount of water from ice cap melt depends on radiation of sun on the edges of the ice cap which may drain into the stream.

Siting of facilities (roads and buildings) on rock or dry frozen permafrost may be desirable, but most construction programs will

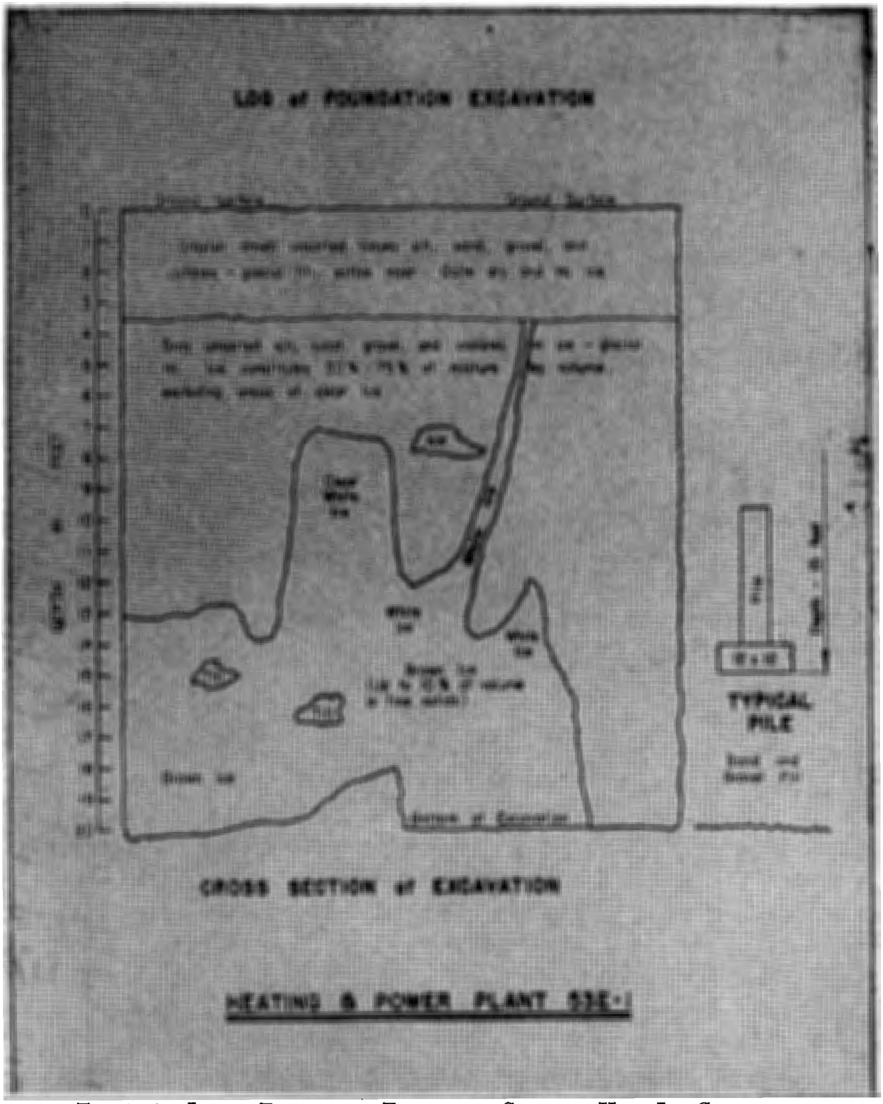



FIGURE 4.—LOG OF FOUNDATION EXCAVATION SHOWING HIGH ICE-CONTENT.

require configurations that will require special consideration to preserve the established thermal regime and protect foundations from thaw.

Permafrost has high load bearing capacity, but when thawed may become a liquid. Increased depth of thaw may be induced by removal or compaction of the active layer, by placement of a heated building or by decreasing the albedo by black top pavement.

Thaw depth into permafrost may be decreased by addition of an insulating layer, by provision for underfloor cooling of building foundations, and by use of reflective paint on black top surfaces.

The most valuable tool of both designer and constructor of sites in permafrost country is called NFS or non-frost-susceptible material. This material is a sand, gravel or crushed rock aggregate containing less than 5% passing the 200 mesh screen.

NFS is used for the insulating layers in fills under building foundations. It is used for upper layers of road and runway embankments. Designers seek to have enough depth of compacted NFS to contain the thaw above the ice bearing permafrost and to carry the imposed loads.

If the siting is such that no such material can be found locally, it must be manufactured or imported. Sources of NFS are similar to sources of good gravel in glaciated areas. Talus slopes generally contain ice and excessive fines. But beaches, river bars and deltas, terraces, kames and eskers may produce satisfactory material. Reconnaissance for NFS is carried on similarly to the search for gravel in the states, by geological study and hand or machine made testpits. Where hand dug test pits are necessary, shaped charges have been effective in opening pits in frozen ground.

Because of the shallow depth of thaw most NFS deposits are scraped and windrowed to give optimum depth of cut for loading units.

Borrow areas should be opened at low point for drainage. There is little seepage except in upper active layer.

Major embankments are not usually constructed until thaw is well along. Even small amounts of ice will preclude high compaction. If permafrost has to be excavated a close follow up of a layer of coarse NFS is made. Shading of excavated areas from sun rays is helpful in keeping slopes from thawing and bottom from becoming muddy.

Permafrost may be excavated like a soft rock. During thawing weather a shaving operation is possible. Rippers and scrapers may expose successive layers and as thaw and excavation proceed the cut may be brought to grade without drilling and blasting. Ripping and scraping are limited by temperature. The colder the material, the more difficult it is to rip and scrape.

Conventional rock drilling and blasting methods are used. Depths of over-drill, shot hole patterns, and loading diagrams are worked out by test shots in the same manner as in rock work.

Drilling may be done in four ways:

1. Drilling from surface through frozen active layer. This is most satisfactory.
2. Drill from surface through thawed active layer. Loose material may fill into hole.
3. Strip active layer and drill in permafrost. This may give a miserably muddy grade to work on, water may leak into holes and refreeze.
4. Strip active layer, place mat on dry sand to get working area, protect permafrost from thaw and minimize hole cave-in. If active layer is relatively thick this method reduces drilling depths significantly.

Unless the ground is very cold and of low ice content it is best to drill only as deep as the drill can drill out. No deeper than longest starter drill carriage will hold. Constant blowing of hole is necessary to keep water and cuttings from sticking to drill. Loading must be done closely behind the drilling before material thawed by the drilling can flow into hole and refreeze.

Forty per cent gelatin is a suitable and versatile powder to use in permafrost and rock, in heat or in cold, and in wet or dry holes. Other explosives including commercial blasting agents are valuable if they can be kept dry.

Powder quantities are sometimes 25–35% higher in pounds per cubic yard yield in permafrost blasting than in hard rock. Hole spacing is generally closer.

For best breakage layered loading with millisecond delays is desirable. If possible the blaster should avoid concentrations of powder at ice layers. Explosive in such case will blow out and melt out the ice layer and not shatter the frozen earth.

Watch shooting line capacity and allow good factor of safety. Misfires are particularly difficult to handle in permafrost because the stemming freezes.

Tunnels in permafrost are experimental in Greenland and of course a practical procedure in Spitzbergen and probably in Russia.

The frozen soil in Thule has been tunnelled for a distance of over 600 feet. Normal shot hole pattern has been followed, the only possible excavation being an angling of the "cut" pattern to throw this material sideways against the rib of the tunnel. Powder yield is comparable to tunnels in soft rock. Material breaks like a conglomerate. The similarity with conglomerate is complete except the cementing agent is ice. This has its benefits. A cobble loosened in conglomerate will stay loosened; but a cobble loosened in permafrost may regelate and become a spare part of the roof or wall. Such tunnels are thus very safe as long as the temperature is below freezing. The mines at Spitzbergen require much fewer props than would be needed in an unfrozen state.

Whether in opencut or tunnel mucking should start right after the blast to prevent the chunks from freezing together. Sheeting or pumping are never required if operations are carried on promptly.

In freezing weather dump truck bodies are heated by circulation of exhaust gases to prevent the muck from freezing to the metal.

Permafrost muck may be used in lower levels of deep fills where high density is not required. Some material which may be unsatisfactory in place because of high ice content may be excavated, spread, thawed, drained and compacted to NFS specifications. Most permafrost muck contains little usable fill and is generally wasted.

## Piling

Driving of wood, concrete or steel piles is impossible in undisturbed permafrost. Piles are set in pre-thawed, pre-drilled or excavated holes. A slurry of water and sand is poured around the piles and allowed to freeze back. Use of steam or hot water to thaw the permafrost to facilitate excavation of pile holes may so warm the area that artificial freezing must be induced to permit early loading of the foundation.

Drilled in caissons are possible and holes for H piles have been drilled with churn drills.

Poles have been set by drilling and blasting holes. Some poles have been set in holes augiered in material thawed by hot water pipes set in wagon drill holes.

Anchors for pole lines and other purposes are easily made by drilling a 12 foot deep hole at the required guy angle, setting in a cable with clamp and knot or a steel bar with washer and nut, and pouring hole full of slurry. The freeze back results in a firm guy anchor.

Driving of piles and sheet piles is feasible under sea water. Dredging by dipper and hydraulic dredges is practical. Hydraulic dredges can circulate water to sluice, thaw and disaggregate frozen layers.

## Névé

The névé of the high polar ice caps is another terrain condition confronting the arctic constructor. This snow and ice may be thousands of feet thick. The Greenland icecap is a great mass of ice and snow piled up like a giant mudpie. Each year an average of three feet of snow falls on the 700,000 square mile area. This snow melts near the edges, but in the interior it accumulates on top of the older snow. The weight added each year compresses the snow below so that it gradually becomes ice. The flow is downward and laterally toward the coasts.

The downward movement in the interior is related to the accumulation. Laterial movement in the interior is minute. Movement is relatively rapid in the glaciers that calve icebergs into the coastal fjords and bays.

For design of icecap stations for ten years life, it is assumed that the icecap is in equilibrium and that the accumulation of snow compresses the snow beneath, the mass moves plastically downward and outward and flows toward the coast where it breaks off as icebergs or melts along the edges. The trip may take thousands of years. Iceberg and melt quantity each year is assumed to equal the water content of the total snow accumulation. The assumption cannot be proved or denied by present empirical means but for the short term life of the stations it is believed sufficiently accurate. Elevation at any point is believed constant from year to year.

The first ice cap stations as built in 1953 were designed to be equal in weight to the displaced snow. Thus they would sink with the sinking of the icecap.

Figure 5 shows one of the sites in 1953, Figure 6 again in 1956 and Figure 7 last in 1960. After seven years the station has been either buried under twenty-five feet of snow or has moved down with the icecap the corresponding amount.

FIGURE 5.—COMPLETED RADAR SITE ON ICECAP—1953.

The icecap stations as built for the DEW Line Extension are not designed as submarines, but as above surface structures which can be raised periodically to keep a constant height above the surrounding snow. These stations sink with the snow and also sink into it. The footings are timber and steel grillages set on the snow in an excavation thirty feet deep. Snow on the icecap becomes denser and of higher bearing capacity with increase in depth. It is not a straight line relationship. For instance snow of 0.5 specific gravity may have seven times the crushing strength of snow of 0.4 specific gravity. This is provided both are at the same temperature and well below freezing. Snow of 0.6 specific gravity may have three times the crushing strength of the 0.5 specific gravity snow and the load bearing strength exceeds 4000/sq. ft.

The raising of the stations 3′ each year is accomplished by jacks. A manometer system provides means of adjusting levels. Some slight differential movement is expected and is adjusted during the yearly raising.

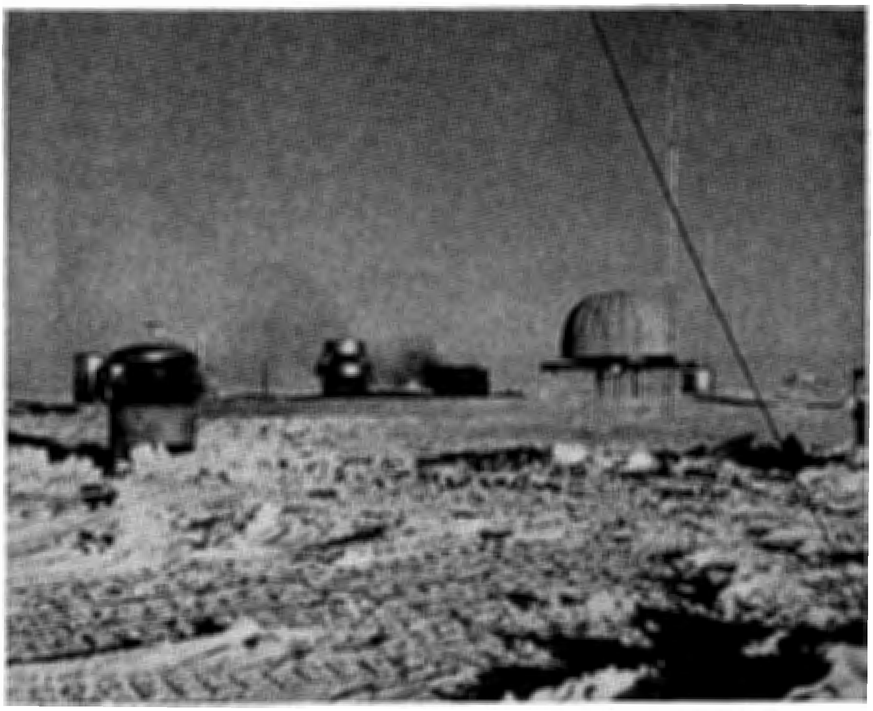


FIGURE 6.—1956 VIEW OF 1953 RADAR SITE.

Despite the features of unique design and the remoteness of the installations lump sum bids from several responsible contractors were received for construction of the stations. The only concession made was agreement to reimburse the contractor if time was lost because of foul weather. Cost due to this clause was negligible.

Excavation for the building foundation and for the buried fuel tanks was accomplished by bulldozers and draglines. The same methods had been used to lesser depths in the 1953 construction. Excavation for poles is easily made by pouring warm water into the snow to melt out hole.

Icecap snow is an ideal excavating medium and requires no pumping, no sheeting, no drilling, no blasting, no overbreak and there is no danger of cave-in or slide. It is readily dug with standard bulldozers

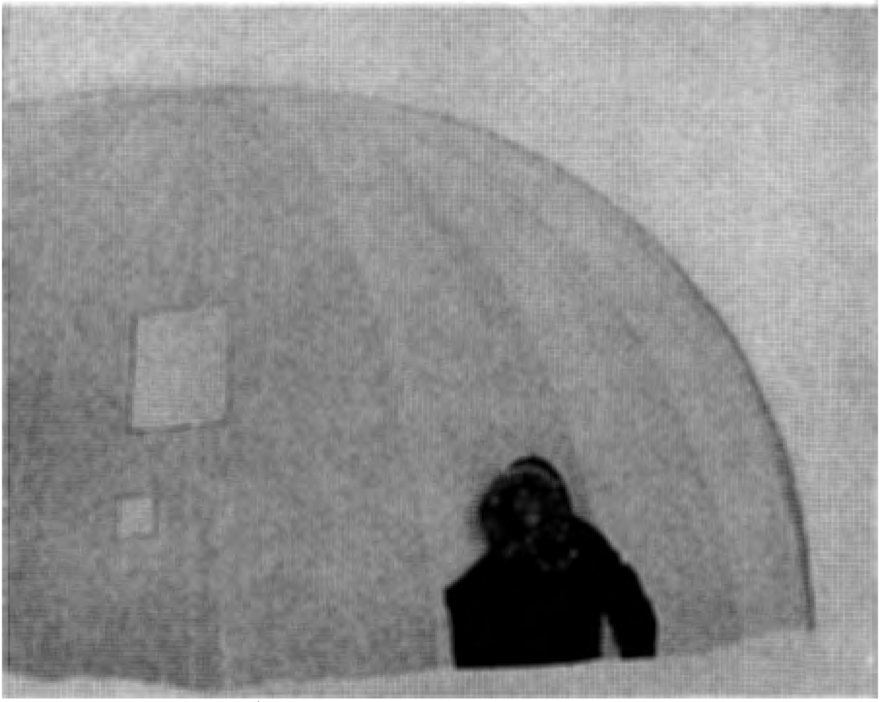


FIGURE 7.—1960 VIEW OF 1953 RADAR SITE.

and draglines. Only modification to tractors working in snow is to slot the track pads over the sprockets so that snow will be pushed out and not ball up in the tracks.

The layers of ice visible in Figure 8 are caused by melt water percolating from surface until it reaches a colder layer and refreezes. In the higher, colder areas of the icecap these layers are practically non-existent.

There are really no unique problems in construction work on the icecap. When the men and machines and material are all there the contractor can dig, dump, set steel, timber, erect panels, build fuel oil tanks, weld pipe lines and conduct operations just as if he were doing cold weather work in Boston.

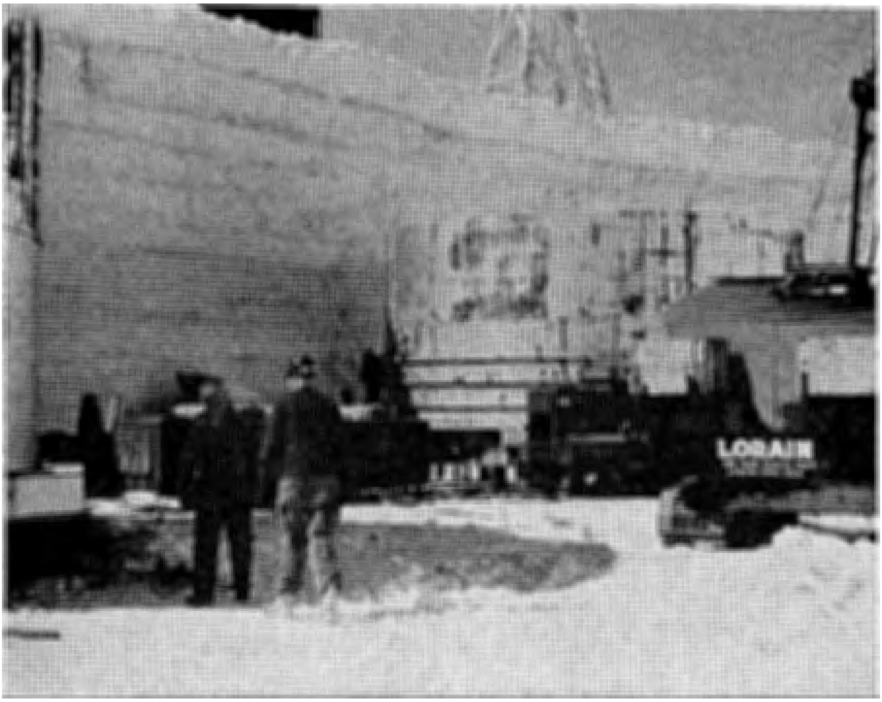



FIGURE 8.—EXCAVATION FOR POL TANKS AT DYE 2 ON ICECAP.

## CONCLUSION

Conventional techniques, familiar to constructors with experience in the North Temperate Zone, are used in the performance of Arctic construction tasks. A few modifications of techniques have been developed in working with permafrost and névé. Logistics require some sort of staging program. Sites already developed provide staging areas for future development. It has become possible to obtain realistic competitive bids from reliable constructors.

A construction contractor who is efficient, well equipped and well staffed will be equally as successful in the Arctic as in the Temperate zone. Successful completion of Arctic work as on any construction work is the result of careful planning, timely delivery of materials and equipment, and on the training, skill and morale of the men on the job.

# SOME HYDRAULIC AND HYDROLOGIC ASPECTS OF THE NIAGARA POWER PROJECT

By Lee Marc G. Wolman,* *Member*

(Presented at a meeting of the Hydraulics Section of the Boston Society of Civil Engineers, held on November 1, 1961.)

## General

The installed Niagara River hydro-electric generating capacity in the United States and Canada exceeds 5 million HP and thus represents the largest local aggregation of electric generation in the world.

It is not size alone, however, that makes the developments at Niagara noteworthy. Unique hydraulic and hydrologic problems confronted the designers of the power projects at Niagara. These arose from the fact that the huge power developments were not permitted to disrupt the famed Niagara cataracts. These continue to demonstrate the awesome force and beauty of nature, as approximately one third of the annual natural river flow plunges 160 feet over the American and Canadian Niagara Falls.

Chas. T. Main, Inc., Boston, through its affiliated partnership Uhl, Hall & Rich, engineered and is supervising construction and offering technical advice on the operation of the most recent and largest Niagara project—that of The Power Authority of the State of New York (1, 2, 3). At this writing (November 1, 1961) eight of the ultimate thirteen units in the principal Power Authority station, the Robert Moses Niagara Power Plant are running—producing about 1,400,000 KW. The first of 12 reversible pump-turbines in the Lewiston Pump-Generating Plant has just gone into operation.

## Niagara River Treaty

Diversions from all the International Waters dividing the United States and Canada are controlled by Treaty (4, 5). Before 1950, Niagara diversions were controlled by the provisions of the original Boundary Waters Treaty of 1909, signed by Elihu Root, Secretary of State of the United States and James Bryce, the great authority

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on American political mores, who was Great Britain's Ambassador to the United States. This treaty provided, among other things, that Canada could divert at an average daily rate of 36,000 cfs from the Niagara River for power purposes, while the United States could divert 20,000 cfs. At the time of the treaty U.S. interests owned the Rankine and Toronto Power developments of approximately 22,000 cfs capacity on the Canadian side of the river and the City of Chicago was diverting more than 5,000 cfs from Lake Michigan through the Chicago Drainage Canal and into the Mississippi basin. During World War II, and later in the 1940's, notes were exchanged between the Governments of the United States and Canada permitting temporary increases in diversions aggregating about 25,000 cfs. These diversions lowered the level of the Chippewa-Grass Island Pool, the wide and deep reach of the river about four miles above the falls from which the high head power diversions are made. Since the river below the pool is relatively shallow on the American side, lowering the pool level caused a marked reduction in the flow down the American Rapids and over the American Falls. During the 1940's a submerged dumped stone weir was built out from the Canadian shore almost half way across the river at the head of the Canadian Cascades, the stretch of rapids above the Canadian Falls. The purpose of this weir was to raise the level of water in the Grass Island Pool in order both to improve hydraulic conditions at the power intakes in the pool, particularly during ice runs, and to increase the flow over the American Falls.

In 1950, as a culmination of over 30 years of discussion and study, The Niagara River Diversion Treaty was signed by representatives of the United States and Canada. This treaty recognized implicitly that the very geological processes that had created the falls refused to stand still and were gradually changing the character of the Canadian Horseshoe Falls to its detriment. What was happening was that erosion was proceeding upstream at a faster rate at the center of the Horseshoe than at its flanks, so that progressively less water was flowing over the flanks. The two governments reasoned that if judicious excavations were made in the river bed along the flanks of the Horseshoe, the scenic beauty of the falls would be enhanced to such an extent that power diversions could be increased beyond those previously authorized without detracting from the scenic beauty of the falls. The 1950 Treaty made provisions for the two countries to construct whatever remedial works would be necessary to enhance the beauty of the falls by providing them with an unbroken crestline. It also required minimums of 100,000 cfs flow over the falls during the daylight hours of the April-October tourist season and 50,000 cfs the rest of the time. The rest of the water was allocated for power—a sizeable amount since the monthly average flows of the river vary between limits of about 250,000 cfs and 170,000 cfs.

Pursuant to the Treaty elaborate surveys were made of the river bed in the Cascades reach of the river and were followed by model tests at the Vicksburg, Mississippi Laboratory of the U.S. Waterways Experiment Station and the Islington Laboratory of the Ontario Hydro-Electric Power Commission, and by model verifications from river measurements. From the model tests, the necessary excavation was determined, as was the need for a control dam just below the submerged weir. The control dam as built consists of 13 bascule gates 100 feet wide by 10½ feet high with 10 foot piers between gates (6). Without this gated dam, it would be impossible to quickly change the flow over the falls in accord with the terms of the Treaty. Also, the dam was designed to make it possible to maintain normal Chippewa-Grass Island Pool levels in the face of the increased pool diversions permitted by the 1950 Treaty. As discussed above in connection with the submerged weir, any lowering of pool levels would reduce the hydraulic efficiency of the existing power intakes and also make the passage of ice runs hazardous. Lowering the pool levels would also increase the required depth and thus the cost of the proposed new intakes. The gated structure permits surging the pool by alternately closing and opening the gates—the sort of operation that is often successful in dislodging ice and getting it to move.

After the 13 gate structure was completed, as a result of changed conditions including the collapse of the old American Schoellkopf plant, it was found that the desired degree of falls control would require lower than normal pool levels. That is, to restrict the falls flow to 50,000 cfs, it would be necessary to keep the pool at lower than expected elevations. Additional model studies were made in 1960-1961 at the Islington Laboratory, as a result of which 5 additional gated bays are now being added to the control structure and training walls are being built parallel to the Canadian shore, upstream and downstream of the dam to funnel ice through and beyond the three inshore gates of the existing structure.

## Lake Erie Outflow

The level of Lake Erie is subject to both an annual cycle and to longer but erratic cycles lasting for many years. Winds and pressure patterns are always acting on the lake to tilt its surface, sometimes toward and sometimes away from its outlet at Buffalo. The tilting effect of wind and pressure at times results in Niagara River flow variations in a single day of greater magnitude than are experienced on a monthly average basis over an entire year.

The Chippewa-Grass Island Pool Control Structure (Fig. 1) is a real asset to the power project. It makes it possible to absorb much of the variation in hourly Lake Erie outflow in the pool. Normal operating practice is to maintain the mean level of the pool at an

Figure 1.—Chippewa-Grass Island Pool in Right Foreground with Control Structure at Its Lower End. Falls at Left Foreground with Ontario Power Plant Just Below Canadian Falls. Power Authority Conduits Pass Diagonally Across Center. (Photo Oct. 21, 1959, courtesy Power Authority of the State of New York.)

elevation appropriate to the flow expected from Lake Erie. The operation of the structure can be illustrated by considering a case where Lake Erie is relatively flat at 9:00 A.M. during the tourist season, 200,000 cfs is coming down the river, the pool is at its normal level for 200,000 cfs, sufficient control gates (about three) are open to permit the passage of 100,000 cfs downstream over the falls and the Power Authority and Ontario Hydro are each withdrawing 50,000 cfs through their pool intakes. If Lake Erie were to now rise quickly at Buffalo, that fact would be telemetered to the water dispatch center located near the falls, apprizing the power entities of the changed situation on the lake. It would then be impractical and indeed impossible for the power entities to so change their power operations as to entirely accommodate such a change in Lake Erie outflow without the passage of any excess flow over the falls. As the increased flow from the lake reaches the pool, the power diversions can remain unchanged, the pool will begin to rise and the control structure gates can be closed sufficiently to prevent the flow over the falls from exceeding 100,000 cfs. The control structure although only "half-a-dam" is most certainly better than none. It controls rather effectively, not just the 4 mile long Chippewa-Grass Island Pool lying below Grand Island but the entire 18 miles of river up to the lower end of the Black Rock Rapids at the Lake Erie outlet. This "reservoir" has an area of approximately 8250 acres and thus a capacity of about 100,000 cfs hrs. per foot of storage. Normally, about a foot of live storage in this pool will be available to alleviate the effects of the vicissitudes of Lake Erie—about half a foot to absorb flows higher than expected and a similar amount to be drawn on for power when flows are lower than expected. Half a foot on the pool is equivalent to about 1/4 of the average volume of water that flows out of Lake Erie each hour.

Two methods of predicting Lake Erie outflows are being studied. For predicting outflows more than a day in advance statistical procedures will be necessary. There are records of many years duration of hourly levels of the lake at both Buffalo and the opposite end of the lake at Toledo. From these records groups of probability curves for each month can be constructed. The curves would assign frequencies to the full range of plus and minus deviations of the Buffalo gage level from the "flat" lake level (Buffalo-Toledo average). Separate curves would be developed for average Buffalo levels ranging perhaps from 3 hours to 24 hours (at 3 hour intervals) and from 2 to

30 days. The lake level at Buffalo, of course, is a good index of the Niagara River flow.

For short range predicting, Ontario Hydro is developing a mathematical model of Lake Erie incorporating the classical equations of hydrodynamics, the empirically determined natural period and damping characteristics of the lake and the effect of wind-induced tangential shear on the lake. It is expected that this model will be reproduced on either a digital or analog computer. Then with the "flat" lake level, the level at Buffalo, and the rate of level change at Buffalo at any instant together with the expected wind direction and intensity (at the lake surface), the expected course of Buffalo levels for the hours ahead could be readily computed.

## Ice

Strong southerly winds blowing across Lake Erie towards the Niagara River outlet when a heavy ice cover on the lake is breaking up can hasten the breakup and cause large blocks of ice to wedge at the lake outlet, thus obstructing the lake outflow. Only rarely does this sort of thing occur to any great extent.

Normally ice from the lake breaks up during winter and spring thaws and floats down the river. The extent of these ice flows varies with the severity of the winter (which governs the ice cover formed on Lake Erie), with the nature of the thaw (whether it is sudden and extreme or gradual), and with wind conditions on the lake at the time of ice break-up. The acts of man can aggravate the ice problem to a considerable extent. In the spring of 1961, ice breakers moved in to open up Buffalo harbor and loosed "icebergs" down the river. These first hung up on the old submerged weir just upstream of the control structure and then threatened to obstruct the intakes to the Sir Adam Beck #2 Plant of Ontario Hydro. Since the new Power Authority plant had just begun operating in February 1961 and had but a few units on the line, the conditions at the Canadian intakes were not as critical as they would have been had the Authority plant been in full operation. There was a relatively large flow of water past the control structure, many of the control structure gates were open and conditions for the transport of ice to the falls were relatively favorable. It was disturbing that, under those conditions, ice represented such a hazard to the Canadian intakes. The model tests at Islington to determine the number of gates to be added to the control structure were also used to study the ice problem. Paraffin blocks, having about the same density as ice, were used to simulate the action of ice. These tests indicated that ice would indeed represent a serious problem and even with the two inshore gates open might stagnate at the Sir Adam Beck #2 intake. Many structures were tried in the model to correct the situation. The final solution was a wall paralleling the Canadian shore as an upstream and downstream extension to the pier between gates 3 and 4. This wall, with gates 1 and 2 and perhaps 3 open, created an ice gathering acceleration channel upstream and an ice escape channel downstream of the control structure. The acceleration channel principle has been successfully used for log sluicing by Ontario Hydro at a number of their northern dams. The Power Authority intake is parallel to the American shore and is of the "draft distributor" (1) type, similar to the Sir Adam Beck No. 2 intake. The ports are about 20 feet below the river surface and the entrance velocities are low. A dike upstream of the intake, that will accelerate surface ice past the intake, and an ice escape channel excavated in the river bed downstream from the intake are expected to produce a sufficient downstream surface current along the shore to carry the ice on the American side past the Authority intake. Whether a strong southwest wind blowing diagonally upstream toward the intakes will have any appreciable effect on ice movements along the American shore remains to be seen.

The treaty requires that 50,000 cfs pass over the falls in the winter, while the power entities have the capacity to divert about 160,000 cfs of ice free water from the Chippewa-Grass Island Pool to the lower Niagara River about 5 miles below the falls. The ice that is carried down to the pool from Lake Erie by the full river flow of about 200,000 cfs will be flushed over the falls by the normal flow of 50,000 cfs, augmented by judicious releases through the gated control structure. The location of the Ontario Power Plant, the Falls Observation Tower (Fig. 2) and other structures near the normal high level of the Maid-of-the Mist Pool appears to make it extremely desirable that ice jams be avoided in this pool (located at the foot of the falls) and that the ice be kept moving into the fast moving Whirlpool Rapids reach of the river. There have been instances in the past when large ice jams developed in the Maid-of-the-Mist Pool when the flow through that pool exceeded 100,000 cfs. It is anticipated that when ice flows are heavy, it will be necessary to release water in excess of the treaty minimum over the falls to keep the ice moving through the Maid-of-the Mist Pool. It will require a "learn by trial" process to determine what is the most economical way to keep the ice moving below the falls.

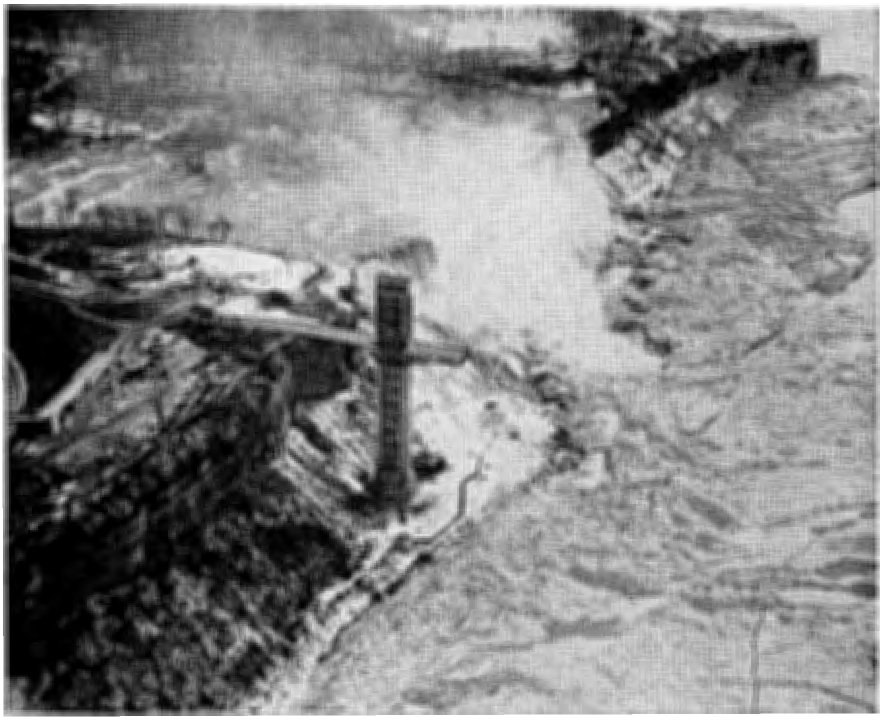

FIGURE 2.—ICE IN UPPER END OF MAID-OF-THE-MIST POOL. U.S. FALLS AND OBSERVATION TOWER. (Photo January 18, 1961, courtesy Power Authority of the State of New York.)

In occasional years there have been ice jams in the lower Niagara River backing up from an ice cover on Lake Ontario. In the spring of 1956 ice was piled almost 40 feet high at the site of the Robert Moses Niagara Power Plant, the Power Authority's main plant. The power house has, of course, been designed to operate safely if such a jam should reoccur. The major ice jams of this kind occur when north winds blowing across Lake Ontario and up the lower Niagara River coincide with the occurrence of an ice cover on the lake and heavy ice runs in the river.

## Hydraulics of the Power Authority Development

To this point, the considerations common to all the power developments on the river have been discussed. Now the operation of the Power Authority project will be considered.

Water at specified but varying rates of flow will be dispatched to the Power Authority by a water dispatching authority—representing the United States and Canadian power entities. This rate will be changed as changes occur in some or all of the various factors entering into its determination, i.e., falls flow requirement, meteorological conditions on Lake Erie, the general level of the lake and ice conditions. The value of the power produced at the project would obviously be seriously impaired if power production were at the complete mercy of this water dispatch—thus, the need for the well-known pumped storage plant at Niagara (7). Not so well-known, perhaps, is the manner in which this plant will operate on an hour to hour basis.

## Scheduling Project Power

The Power Authority has contracted for the sale of the power produced at the project at rates which guarantee the payment of the interest on and the amortization of the principal of the outstanding revenue bonds that provided the funds necessary to build the project. All the bonds were offered to and purchased by the public. The most economic use will be made of the water power available at the project. The power contracts provide that rural and domestic customers in the market area of the project who buy project power from the large utility purchasers of Niagara power shall be credited with any savings that accrue to the utility companies by virtue of the difference in cost between Authority power and the most economic alternate sources of thermal power for supplying the rural and domestic loads. Optimizing the hourly scheduling of steam generation in a utility system with no hydro resources is no simple problem. Adding hydro to the process complicates matters but does not render the problem insoluble. Operating the Niagara Project in such a way as to minimize, to the greatest practicable extent, the cost of thermal generation in the interconnected system, precludes changing the project load every time the water dispatch changes. An economic scheduling of hourly project loads must be accomplished when no one knows exactly what Lake Erie will do.

Thanks to the Lewiston Pump-Generating Plant this fact is not too disturbing. Consider, for example, a situation where river conditions dictate a 3,000 cfs cut in the Power Authority diversion rate in the face of a 23 megawatt load increase at a time when the Pump-Generating Plant is generating. The plant operators would first obtain the reservoir, forebay and Niagara River tailwater levels and then assume that the entire 23 MW increase were generated at the Robert Moses Plant. Under that assumption, however, an additional 1,000 cfs would be diverted from the Niagara River and the Authority would then be diverting 4,000 cfs more than its allocation. One Lewiston generating unit at best gate, with the observed Reservoir, forebay and tailwater levels, however, can furnish power at Lewiston and water for power at Moses equivalent in total to the power produced by about 4,000 cfs at Moses alone. Thus, the proper operation to keep the hydraulic system in balance is to put another Lewiston generator on the line at best gate. Electronic load-frequency control equipment sensing the Lewiston and Moses Plant generations and the desired project output will automatically impulse motors on the speed level devices of the Moses governors until the Moses units are at the proper load (desired project load less Lewiston generation).

## Surges in Forebay Canal

The 71 acre Forebay Canal (Fig. 3) acts as a simple surge tank for the two conduits that lead Niagara River water to the Moses and Lewiston Plants. Each of these conduits is 46 feet wide, 66 feet high and about 4 miles long. The combined conduit cross-sectional area is 5616 square feet. Equilibrium in this system is reached when the flow through the conduits equals the draft on the Forebay Canal. Whenever there is a change in the forebay draft, such as occurs when there is a load change on the Moses Plant, the immediate effect is to change the elevation of water in the forebay. The inertia represented by the water flowing in the conduits is large in amount and relatively slow to change. The large forebay, sized with this in mind, and the conduit friction (Manning's "n" of approximately 0.012) lead to rapid damping of surges. On sudden increases in draft even of large amounts, surges are damped in less than two hours. On decreases in draft, since conduit friction is relatively small at the end point, complete damping may take a few hours longer. The time of the first quarter cycle of these surges is about half an hour. That is, it takes about half an hour after a sudden load change for the forebay level to make its maximum change.

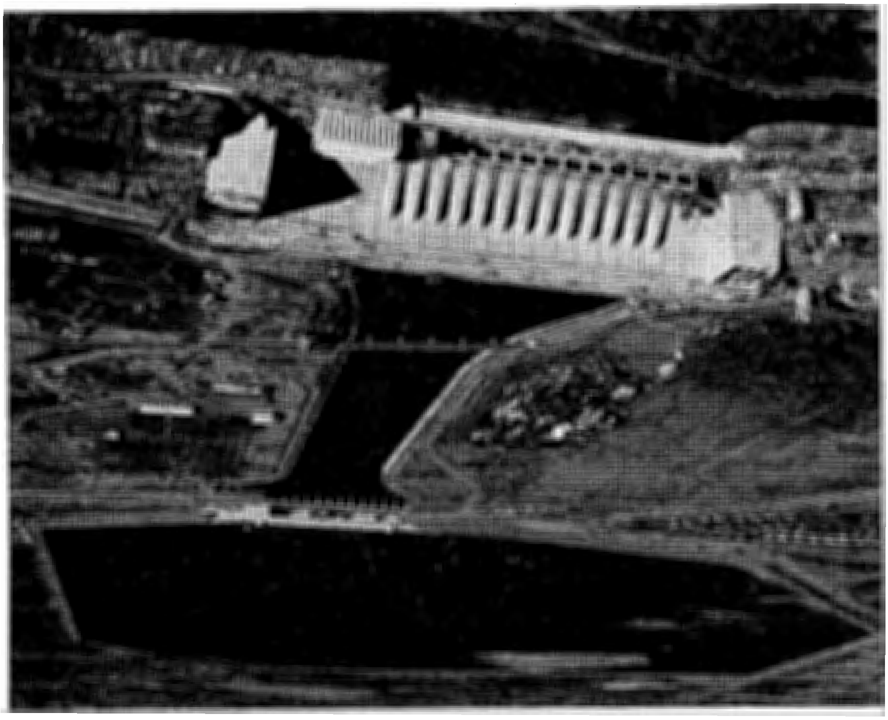

FIGURE 3.—IN CENTER IS 71 ACRE FOREBAY CANAL, BELOW IT IS MOSES PLANT, ABOVE IT LEWISTON PUMP-GENERATING PLANT WITH 1900 ACRE RESERVOIR. CONDUITS DISCHARGE INTO FOREBAY CANAL AT UPPER RIGHT. (Photo November 29, 1961, courtesy Power Authority of the State of New York.)

## HEAD LOSS IN CONDUITS

Actual head losses in the conduits are about the same as those computed during the design of the project. As mentioned above the estimated roughness corresponds to a Manning's "n" of 0.012. Conventional bend loss formulas were assumed, and model losses were available for both the intake to and the exit from the conduits which were designed for best efficiency in the Islington Laboratory of the Ontario Hydro-Electric Power Commission. The maximum practical capacity of the conduits is as yet unknown. This limiting capacity, well above the design criterion, is expected to occur at some flow above 100,000 cfs, with conduit flow becoming unstable and the conduits alernately flowing full and part full causing the forebay to fluctuate severely. At 50,000 cfs, the head loss from river to forebay is about 4.5 ft.; at 100,000 cfs it is expected to be about 18 ft. Because of the large area of the forebay, if it were desired to divert an average of 50,000 cfs from the river for an hour following a diversion rate of 100,000 cfs, it would be necessary to change the forebay draft at the start of the hour from 100,000 cfs to about 40,000 cfs, and to maintain that 40,000 cfs for the hour.

## Digital Computer Applications

As the multitude of studies related to operating the Niagara Project have been carried out, numerous applications have been found for digital computers. As one result of these studies a 16,000 word magnetic drum computer system will soon be installed at the Moses plant. It will dictate the operation of both the Lewiston and Moses plants in compliance with the two disparate requirements of water diversion and power production, and will also log hydraulic and electrical operating data and alert the plant operator to the need for rescheduling plant loads in the face of an impending empty or overflowing reservoir. The simple surge tank problem was programmed for direct solution using second derivatives and numerous surge studies have been made with a minimum of labor. Various tabulations that greatly facilitate operating studies have been made by computer. The statistical analyses of lake levels at Buffalo, mentioned previously, would be extremely time consuming and expensive were it not for the availability of digital computers.

## Conclusion

The great developments alongside the scenic spectacle at Niagara are appropriate monuments to the art and science of hydraulic engineering. The design of these developments required and their operation involves recognition of a variety of natural and artificial variables. These range from meteorological influences on Lake Erie and the Niagara River to hydraulic transients in the conduit-forebay systems of the high head power developments, and from the treaty requirements for falls flow to the characteristics of the interconnected electric systems in the region.


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# FOX POINT HURRICANE BARRIER

By John Wm. Leslie,* *Member*

(Presented at a joint meeting of the Boston Society of Civil Engineers and Structural Section, B.S.C.E., held on December 13, 1961.)

The Narragansett Bay area of Rhode Island and Massachusetts, exposed as it is to the Atlantic Ocean on the south, has experienced very heavy tidal flood losses due to hurricanes. Hurricane tidal surges are funneled into the Bay and flood densely populated and developed areas especially in the vicinity of Providence, Newport, and Fall River. Recurring flood losses are estimated at approximately $120,-000,000 for the September 1938 hurricane, and $92,000,000 for the August 1954 hurricane. Loss of life has been great with over 250 lives lost in Narragansett Bay and along the Rhode Island coast during the 1938 and 1954 hurricanes. The need for protection is urgent, particularly in Providence, the capitol city and chief commercial center of Rhode Island where a recurrence of the 1938 flood alone would cause $42,000,000 of damages at today's pricing.

As a result of this serious problem of hurricane tidal flooding, the Congress in 1955 passed authorization permitting the Corps of Engineers to make a study of this heavy damage area to resolve the problem in the most expeditious and least costly manner. Operating on these instructions, the New England Division, Corps of Engineers, in 1957 submitted a report with its findings on the resolution of the problem. This report basically recommended two features (Figure 1): one, a proposed Lower Bay Barrier, and secondly, a local barrier at Providence. The Lower Bay Barrier was aimed at protection of the entire Narragansett Bay whereas the upper barrier at Fox Point was specifically directed toward reducing the damages to the City of Providence. The report was favorably acted upon in 1958 and at that time authority was granted for the design of the Fox Point project and continued studies on the Lower Bay Barrier. It is noted that the Fox Point Barrier was to cost in the neighborhood of $16,000,000 whereas the Lower Bay Barrier would cost approximately $80,000,000. It may

* Chief, Engineering Division, New England Division, Corps of Engineers.

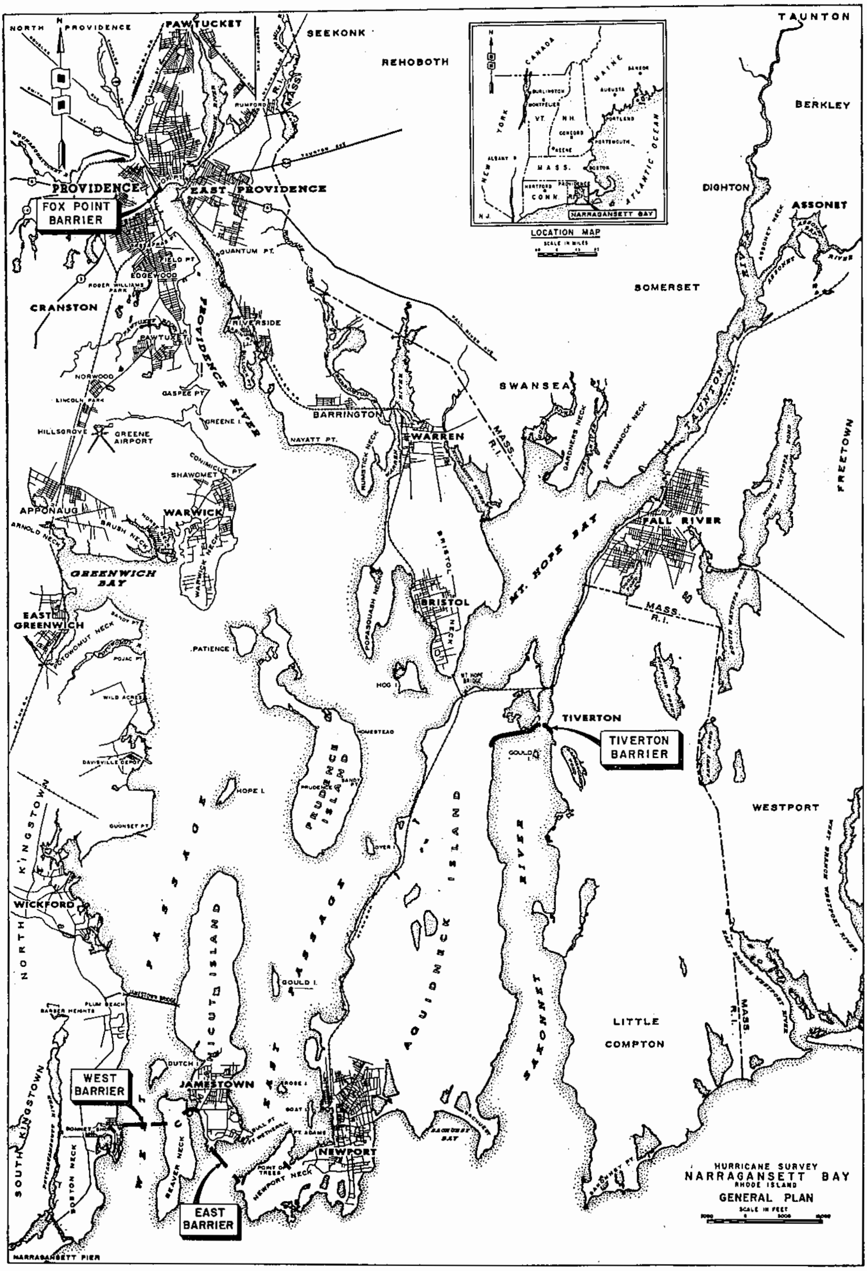

TAUNTON
NORTH PROVIDENCE
PAWTUCKET
SEEKONK
REHOBOTH
BERKLEY
PROVIDENCE
EAST PROVIDENCE
FOX POINT BARRIER
DIGHTON
ASSONET
SOMERSET
CRANSTON
LOCATION MAP
NARRAGANSETT BAY
PROVIDENCE RIVER
RIVERSIDE
SWANSEA
BARRINGTON
WARREN
FREETOWN
GREENE AIRPORT
WARWICK
FALL RIVER
MT. HOPE BAY
GREENWICH BAY
BRISTOL
EAST GREENWICH
TIVERTON
TIVERTON BARRIER
WESTPORT
PRUDENCE ISLAND
WICKFORD
NORTH KINGSTOWN
AQUIDNECK ISLAND
SAKONNET RIVER
LITTLE COMPTON
CONANICUT ISLAND
JAMESTOWN
WEST BARRIER
NEWPORT
EAST BARRIER
SOUTH KINGSTOWN
NARRAGANSETT PIER
HURRICANE SURVEY
NARRAGANSETT BAY
RHODE ISLAND
GENERAL PLAN

FIGURE 1.

occur to some what was the need of Fox Point if the Lower Bay Barrier plan was to be executed. The Fox Point Barrier is analagous to local protection in fresh water flooding whereas the Lower Bay plan is similar to a reservoir. Many times, local protection must supplement the reservoir as additional protection and in this instance the Fox Point project is necessary to supplement the Lower Bay plan to protect against residual conditions; in this case, the wave action due to wind effects of the long fetch of the bay. Again, the substantial amount of monies required to build the Lower Bay plan indicated that they might be long coming whereas the need for protection of Fox Point was necessary immediately.

Design against hurricanes is a brand new field of engineering and there is very little information upon which the designer may draw to produce his finished product. As a result, the Corps of Engineers, in attempting to develop criteria, worked along two major fronts. One, the creation of a physical scale model of the entire Narragansett Bay. This was done at the Corps of Engineers Waterways Experiment Station at Vicksburg, Mississippi. Here, a model was constructed that was of such magnitude that it required the majority of space afforded by an airplane hangar approximately 300′ × 300′. Here all the tidal conditions and wind velocities that might occur in the Narragansett Bay were simulated and here was developed the data that would be needed for the design of both the Fox Point project and the Lower Bay Barrier. Secondly, a mathematical model was formulated at Texas Agricultural and Mining School where similar check data were made on a mathematical basis.

## Description of Barrier

The Fox Point Hurricane Barrier is located just below the City of Providence. It crosses the bay of the Providence River and is composed of several features that I will describe in generalities. The total length of the hurricane barrier is just under 3000 feet. There are (a) 2,200 lineal feet of earth dikes, (b) 290 feet of a non-overflow concrete barrier, (c) 3 tainter river gates, 40′ × 40′, with the sill at minus 15 feet MSL, (d) a pumping station 214′ × 91′, with five 120-inch diameter pumps. The total pumping capacity of the five units is 7,000 cubic feet per second. The pumping station, incidentally, is to expel the inland run-off occurring during hurricane conditions from an approximate 77 square-mile drainage area, (e) three vehicular gates totalling 125 feet in length, located at Allen's Avenue, Narragansett Electric Company and at South Main Street on the east side of the river. These features are clearly shown in the photograph of the proposed project (Figure 2).

FIGURE 2.—THE FOX POINT HURRICANE BARRIER, PROVIDENCE, R. I.

## WORKING CRITERIA

a. The normal tide range at Narragansett Bay is plus 2.47 feet to minus 2.13 feet.

b. The stillwater elevation used in the design of the Fox Point Hurricane Barrier is elevation 20.5 feet mean sea level.

| | |
|---|---|
| Surge at Newport | 11.2 feet |
| Dynamic buildup | 3.3 feet |
| Wind setup | 2.9 feet |
| Coincident tide | 3.1 feet |

c. Freeboard of 4½ feet was allowed for this project to take care of as much wave overtopping as was economical. This, therefore, establishes the top elevation of the barrier as 25.0 feet above mean sea level. It was not economically possible to take care of all overtopping. We may expect as high as 350 cubic feet per second from wave overtopping. However, this is not serious inasmuch as it can be easily taken care of by the pumps in the pumping station which, as mentioned above, have a capacity of 7,000 cfs. It may be of interest to some, that the significant wave height was 6½ feet with a period of 5.5 seconds.

## Cooling Water Canal

Our early studies of the Fox Point project indicated that construction and later being of the barrier might cause trouble with the going plants of the Narragansett Electric Company. The excavation that would be needed in the channel in order to place the concrete structures is of an organic content and therefore could easily create a sulphide condition which could easily be taken into the plant through the cooling water intake pipes and cause pitting to the condenser tubes. This, of course, would be damaging and would result in damages that might be assessed against the Government and its contributing partners. Secondly, our studies at the Waterways Experiment Station indicated that there would be a rise in the temperature of the water impounded behind the barrier which would affect the efficiency of the generating units. In order to circumvent this, a cooling water canal was built along the pier of the Narragansett Electric Company. This permits the taking of the cooler bay waters into the plant at all times. As you may note on the photograph, the cooling water canal extends downstream of the barrier where it constantly takes its water from the bay.

The total cost of the Fox Point Hurricane project is now estimated at $15,900,000, of which 30%, by law, is required to be paid by the local interests. In this particular instance it will be jointly subscribed by the City of Providence and the State of Rhode Island. This amount of 30% is approximately $4,740,000. All Corps of Engineers projects and those of other Government agencies too, are evaluated on what is known as a B/C ratio, i.e., the ratio of the annual benefits to the annual costs. In order to be an acceptable project, this should exceed a ratio of one. In the instance of Fox Point, the annual benefits are $1,786,000 and the annual costs $732,500. This, therefore, gives the project a B/C ratio of 2.4 to 1 which is well above the criterion for an acceptable project.

The Fox Point project is now under construction and is expected to be completed early in 1964. However, it will be operational in late 1963 should a hurricane occur. The project will be operated by the City of Providence with advice and guidance by the Corps of Engineers. Construction of the project as indicated above will forever free the City of Providence from damages resulting from forecastable hurricanes which, as stated previously, could exceed $42,000,000.

# STRUCTURAL ASPECTS OF FOX POINT HURRICANE BARRIER

BY H. E. WHITTEMORE*

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Structural Section, B.S.C.E., held on December 13, 1961.)

THE design and construction of hurricane barriers are new engineering fields that the Corps of Engineers has become engaged in and the New England Division is pioneering this effort. This is particularly true when considering the structural aspects. It was found on initiating the Fox Point Design, that we could draw on very little past experience in the design of hurricane resisting structures. Also, some types of structures that we have successfully used for many years on local protection projects, would not withstand the heavy wave loadings.

The starting task, therefore, was the development of the loading and structural criteria by which the design of the various structures could be accomplished. First the nature of the hurricane loading was examined. This is composed of the wind, naturally, and also some type of water and wave loading. It was decided after considerable research of the available information on wave loadings that Technical Report No. 4 (Shore Protection and Planning) prepared by the Beach Erosion Board contained the best information for our use. This is a voluminous report that has just been reprinted after being out of print for some time. This report contains methods whereby the forces from three principal types of waves can be computed. These are the broken wave, breaking wave and a clapotis condition where the wave does not break but runs up the structure.

Figure 1 shows the force diagrams for the latter two conditions which were the most prevalent ones used. The left hand diagram shows the force from a breaking wave against a structure such as the street gates. This is a loading derived from the so called Minikin formula. The large parabolic force application is something to contend with as you can see. This formula has long been considered on the over con-

* New England Division, Corps of Engineers.

servative side and often results in members or structures unreasonably large. It also does not adequately cover approach slopes that are almost flat. However, as the structures in the barrier are highly critical and a structural failure in any element could mean the loss of the protection we were forced to use it even though it might be over conservative. As far as Fox Point is concerned the structures did not become unreasonably large. Some were large to start with. The effects of breaking waves on structures is a good field for a research project to improve the present limited data.

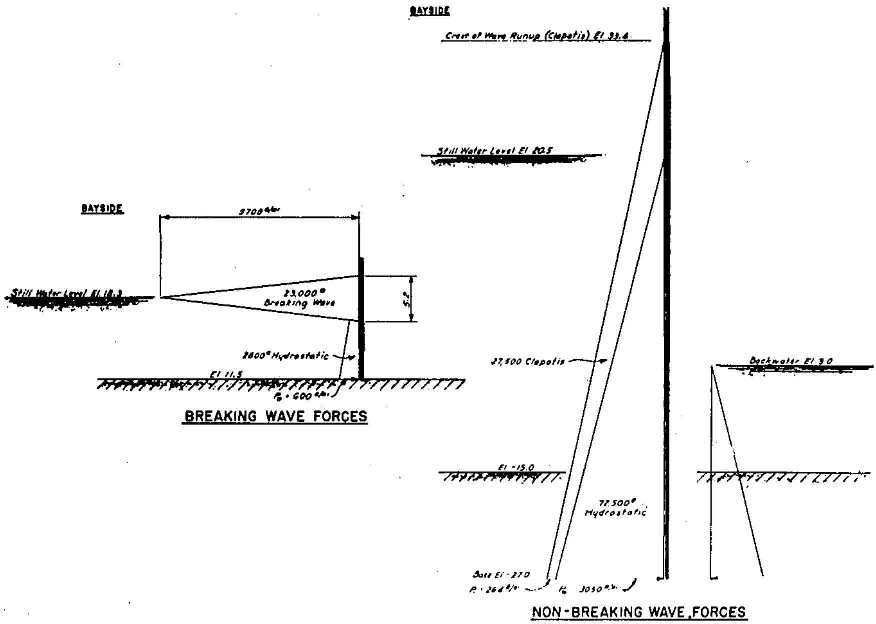



FIGURE 1.

The right hand diagram shows the maximum clapotis condition in the deep water. Here the stillwater is at the maximum design stillwater level of 20.5. The definition of clapotis is a deep water wave reflected from an obstruction, and the crest of the clapotis is the top of the wave. We might also say that it is the maximum run-up on the structure. The determination of this wave loading is by the Sainflou formula which is considered reasonably good.

The broken wave diagram is not shown, but is somewhat similar to the breaking wave but on a smaller magnitude and is a uniform force application instead of a parabolic one. The lateral forces applied to the structures are of considerable magnitude for all three cases. The question of when to use each of these type loadings is best answered by stating that in the deep water the waves will not break and the clapotis condition applies. When the stillwater level reaches the right depth where the wave will no longer sustain itself, it breaks and at that point the breaking wave force is used. Once the depth is such that the wave has broken, the use of the broken wave is obvious.

The next consideration was that of working stresses. In general, the working stresses set forth in the A.I.S.C., A.C.I. and in some instances the A.A.S.H.O., were used. When considering storm conditions and construction conditions the basic stresses were increased by 33⅓% except for allowable pile loadings which were increased by 50 percent. The 50 percent increase in pile loading is arbitrary and it should be added that since the preparation of the design, test piles have been driven and loaded with at least twice the basic load before application of the increase, without appreciable deformation. As far as allowable unit stress in the steel bearing piles, the Boston Building Code value of 7500 lbs. per sq. in. was used for the compression piles and a value of about 200 lbs. per sq. ft. applied to the rectangular perimeter times the length was used in the determination of the tension for the tension piles.

Time will not permit a detailed discussion of the design of all the structural items composing this barrier so my remarks will be confined to the three principal structures. The first of these is the pumping station. The structure has been divided into four monoliths which was done principally to control shrinkage and expansion forces in the massive sub-structure and to also provide units that might facilitate the contractors work. These expansion joints do not go through the foundation mat which will be constructed as a single continuous mat approximately 214 ft. in length.

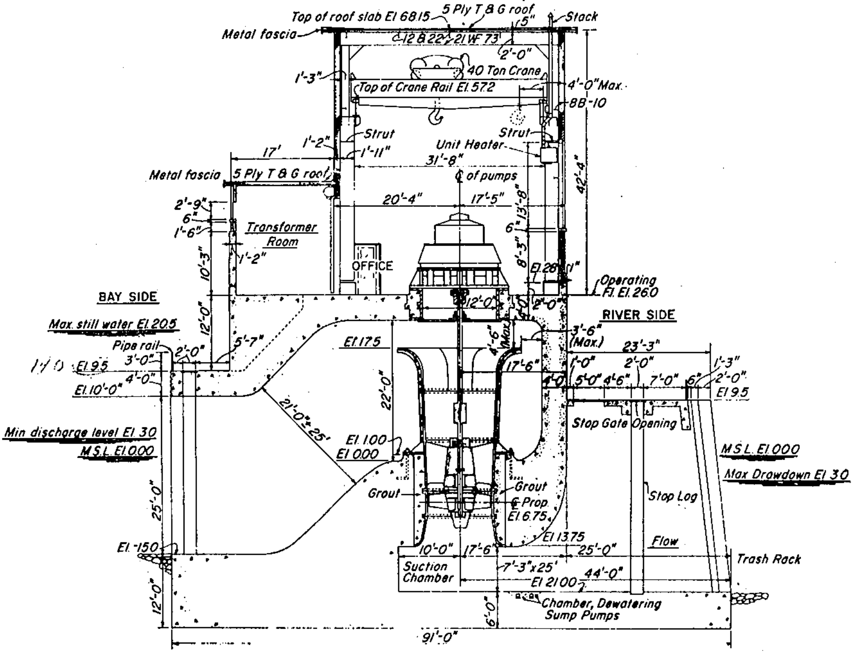
Figure 2 shows a typical cross section thru one of the pump bays showing the massiveness of the substructure. The presence of the platform at elev. +14.00 will trigger some waves so that they will break against the face of the structure.

There were six basic conditions investigated for stability.

Case I. The construction condition with just the dead weight of the structure and no lateral loading.

Case II. A storm condition using a breaking wave on the bayside and tailwater on the riverside at +3.0.

Case III. Also a storm condition using maximum wave with clapotis at elevation +33.3. A 30 lb. wind on the superstructure and tailwater at +3.0.




**FOX POINT HURRICANE BARRIER**

**PUMPING STATION**

FIGURE 2.

Case IV. Same as Case III, except the tailwater at elevation —3.0.

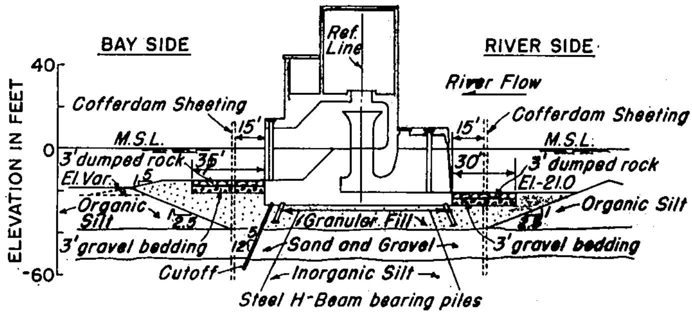
Case V. The normal everyday condition.

Case VI. An earthquake investigation as applied to the normal condition.

The stress analysis of the substructure was accomplished principally by analyzing a series of longitudinal sections and designing them as continuous frames. The superstructure utilizes built up steel columns stepped back to accommodate the crane brackets. The roof is a concrete slab on steel purlins framing onto the steel bents.

There is a deep band of inorganic silt overlaying till, beneath the structure which becomes fluid like quicksand when disturbed. It was decided we could not found any of the structures in this material or the material above for fear that future operations in the area might disturb the silt and cause our structures to settle.

Figure 3 shows a cross section through the pumping station showing the bottom treatment under the station. Heavy steel H piles were selected over concrete piles principally because of the necessity for battering them and because they would cause less disturbance of the inorganic silt when they were driven.




**TYPICAL SECTION AT PUMP STATION**

FIGURE 3.

Figure 4 shows the method of analysis used for the steel piling. As can be seen the large horizontal forces require an arrangement of batter piling in each direction. This is an elastic center analysis known as the Vetter method which divides the piles into groups, substitutes a dummy pile for each group and graphically finds the elastic center of the groups. The resultant of the horizontal and vertical forces is then plotted. Basically it is then the old $P/A \pm Mc/I$ formula where P is the vector force in the direction of each batter group where M is the force times the distance to the elastic center, c is the measured distance between any pile and the dummy pile, and I is the polar moment of inertia of the piles about the elastic center. It was found that the maximum compression pile load is 252 kips, there were no piles in tension and that there would have to be 532 piles required for the pumping station. The piles are BP 14 89 lbs. and will be 70 to 80 ft. in length.

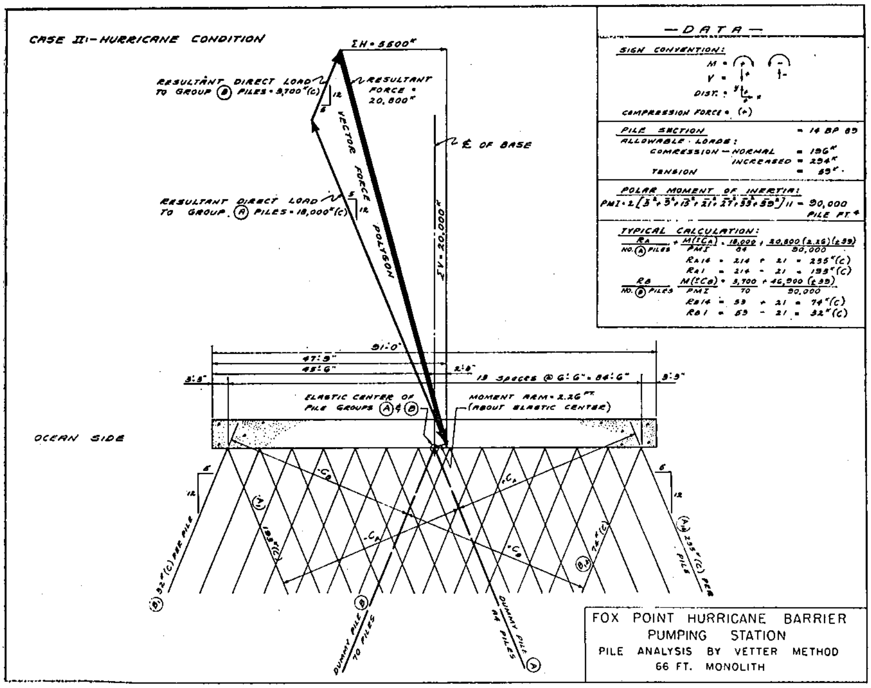
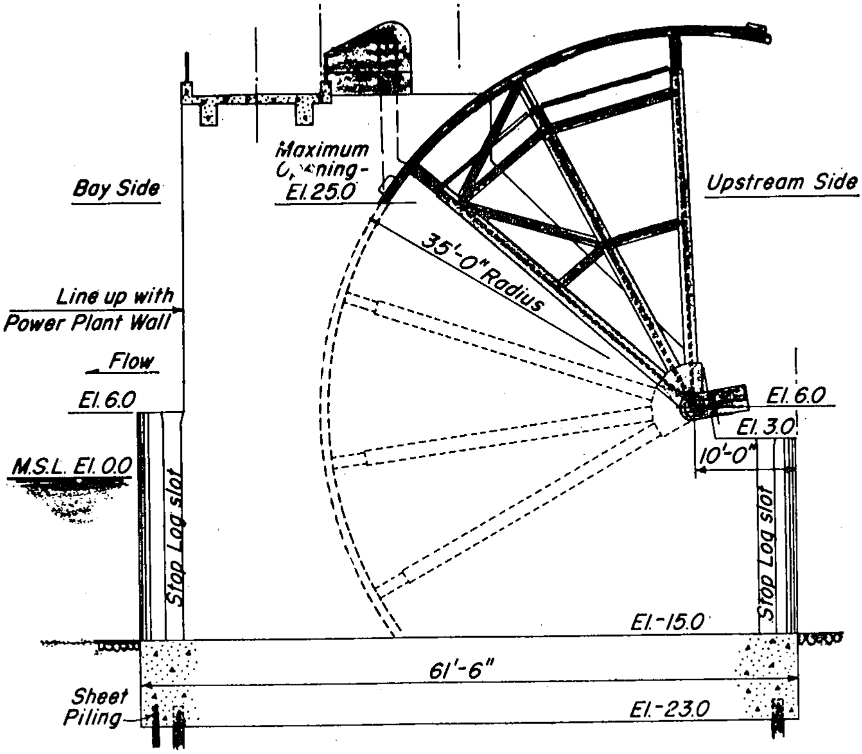



FIGURE 4.

Figure 5 shows a cross section thru the river gates. There are three 40 ft. wide tainter gates which when in a closed position block the river from elev. +25.0 to —15.0. The side frames are inclined in order to reduce moments in the longitudinal face beams. The skin plate will vary in thickness from 3/8″ to 1/2″ and spans between vertical tee sections. The anchorage of the gate will be accomplished by using a post tensioned system of rods where under no condition of loading will the concrete under the thrust girder be in anything but compression. Tensioning will be accomplished at the thrust girder end and after tensioning the tubes will be filled with grout. The concrete in this area will be 4000 lb. concrete. This is an anchorage system recently adopted by the Corps for new projects and which has already been incorporated into several large projects. It is a great improvement over the old type anchorage which employed a steel grillage system carrying the gate thrust in tension down some distance into the pier.

This is a relatively light structure to be carrying the large horizontal loads applied under a hurricane condition. Here again systems of batter piling in tension or compression and analyzed by the Vetter method were used. The design of the base slab was a sizeable problem because of the light weight of the structure. The base slab was de-



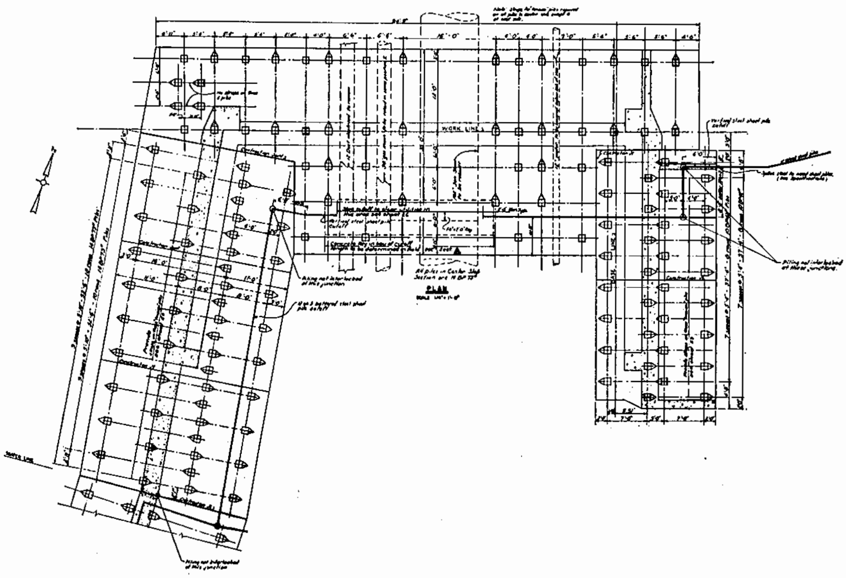

**FOX POINT HURRICANE BARRIER**

**TYPICAL SECTION RIVER GATE**

FIGURE 5.

signed as a series of longitudinal bands. The pile reactions and the piers were treated as loads on the bands. The slab will be 8 feet thick and will use No. 14s and No. 18s reinforcing rods to take care of the very high moments developed. The use of smaller size rods would have resulted in additional layers of steel at a close spacing and might have given considerable difficulty in placing the concrete. Lap splicing of the large bars has been eliminated and it will be accomplished by welding using the thermit type weld.

The street gate structure required to close off Allens Ave. and South Main Street also developed into major structural problems. At Allens Ave. where the clear distance between abutments is 67 feet, there had to be some type of gate structure developed that could be closed in as rapid a time as possible. Figure 6 shows the foundation




FOX POINT HURRICANE BARRIER
ALLENS AVE. STREET GATE
FOUNDATION PLAN
FIGURE 6.

plan of the Allens Ave. gate. The wave application is at an angle to the gate and the shape of the center monolith crossing the roadway is worth noting. The Tee shaped section was selected so as to eliminate the wing wall projections which are at right angles to the gate. If the wing walls had been made a part of the gate section there would have been wave forces in two directions making the pile analysis considerably more difficult. By this arrangement all the wave forces on the gate are directly up the street in the case of the center slab and normal to the wing walls for the side monoliths. This makes the resultant force parallel to the pile groups although not necessarily concentric with the group and makes the analysis readily computed.

Figure 7 shows two elevations of the gate framing. There are

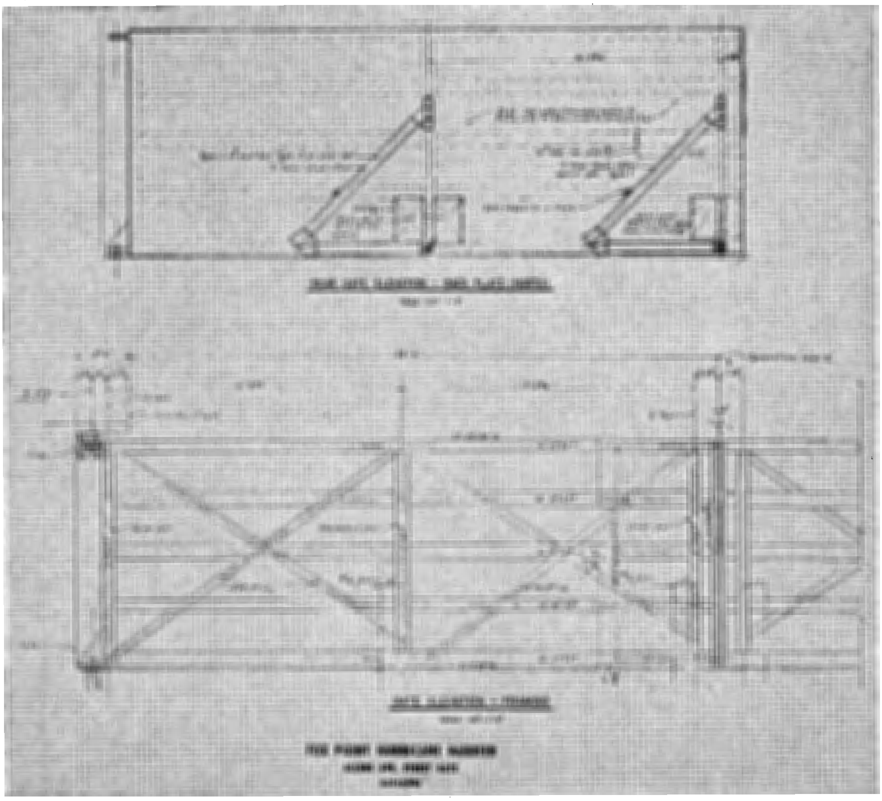


FIGURE 7.

five horizontal beams required to transmit the wave forces into the A frames and the abutments. The skin plate is 9/16″ thick hi-strength steel and frames to the 16″ WF horizontal members. The lower hinge will take the weight of the gate and the upper hinge the pull when it is being swung. The A frames are shown here as folded back against the gate as they will be when in the stored position. When the gate is pulled out into the road the A frames swing out and are fastened down to a weldment in the road as shown on Figure 8. The tie down bolt at the gate is hooked into another weldment in the road and brought up tight. In addition, jacks contained in the gate are screwed down onto the sill taking the weight off the hinges. Although this is a heavy gate, each leaf of which weighs 10 tons, there are few assembly parts to be fastened at time of use and with proper training of crews, the gate should be in place in short order.

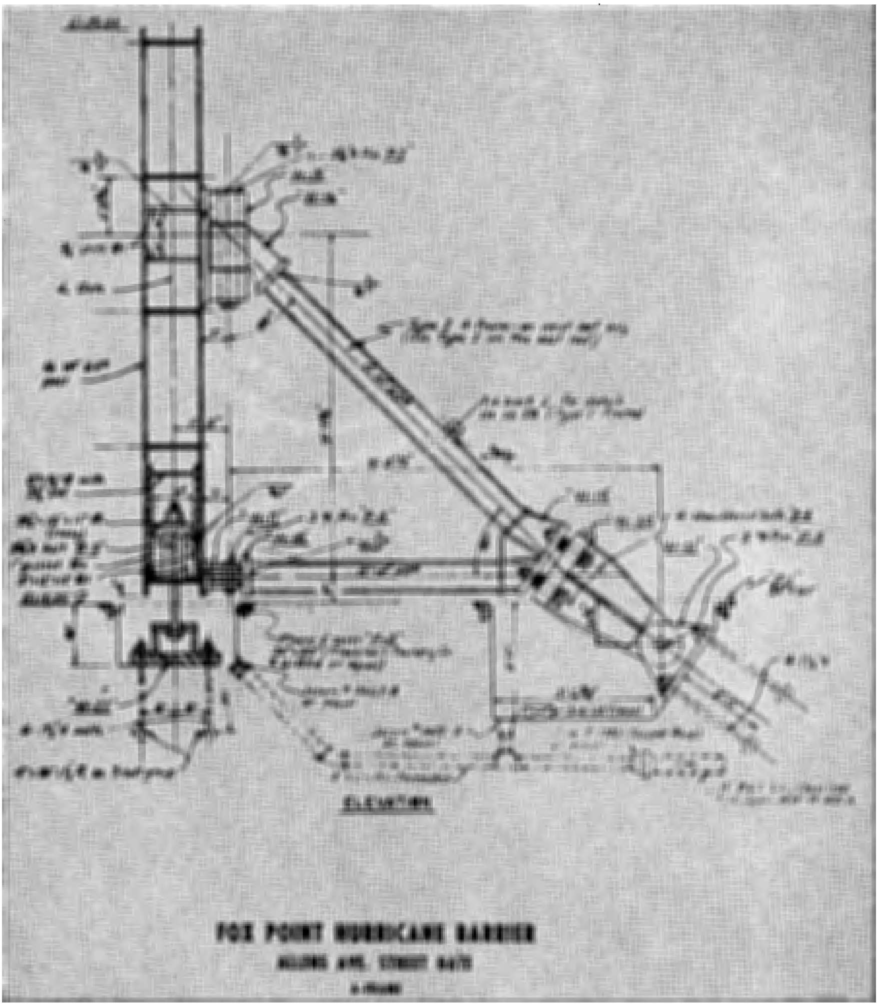


FIGURE 8.

In closing it should be stated that this first hurricane design was a challenge structurally. The wave loading and criteria developed and used are considered sound and the type and shape of structures selected such as the street gates are considered adequate to resist the battering they could receive from a hurricane. It should also be stated that our present projects are even more of a challenge but we expect to improve several of the features, such as street gates so that the closing time can be reduced to an absolute minimum.

# FOX POINT PUMPING STATION: MECHANICAL & ELECTRICAL FEATURES

By Eugene Groden*

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Structural Section, B.S.C.E., held on December 13, 1961.)

This will be a brief outline of the mechanical and electrical features of the pumping station which forms a part of the Hurricane Barrier.

Hydrology studies of the water shed established the design flood of 7,000 c.f.s., a rate close to 200 million gallons per hour. This represents the inflow at the barrier which the pumping plant must be able to lift against the hurricane ocean tides. The design operating head is 20 feet, representing the differential between the maximum hurricane tide still water elevation and the Providence River stage of 0 m.s.l.

Five 120″ diameter, 164 rpm pumps, each rated at 1400 c.f.s. at 20 foot head will provide the required capacity. An item about the Fox Point project in the September 7, 1961 issue of the *Engineering News Record* referred to these pumps as the largest ever built. This is not quite true, as I understand that there is a pump in service at Grand Coulee Dam capable of delivering 1500 c.f.s. at a head in excess of 20 feet. In this respect, therefore, we cannot claim to be pioneering.

Selection of five units is predicated on considerations of overall economy and the range of anticipated river flows. Although a greater number of smaller units would cost less, because these could be designed to operate at higher rotating speeds, the savings would be more than offset by the higher cost of the structure to house the pumps. A lesser number of larger units would sharply raise the equipment cost. Moreover, the higher capacity of each pump would result in a pumping rate excessive for conditions other than very severe floods and bring about undesireably short pumping cycles and unwieldy operating conditions.

Figure 1 is the floor plan of the pumping station with the five

* New England Division, Corps of Engineers.

pumps arranged in line on 33 foot centers. The structure is approximately 214 feet long, 38 feet wide and 95 feet high from bottom of base slab to the roof. The west end of the station accommodates two control gates for the cooling water canal provided for the Narragansett Electric Company, which was mentioned earlier this evening.

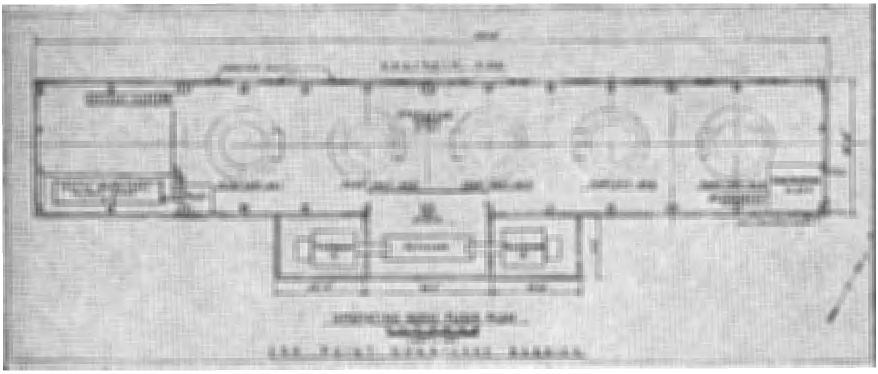


FIGURE 1.

The pumps (Figure 2) are of the vertical flared tube design. This design was adopted rather than the more conventional draft tube arrangement because of its simplicity and low cost. The pumps will be loaded so infrequently and then for so brief a period that costly refinements in pumps or water passages for gain in efficiency, such as forming and fabrication of elaborate curved surfaces characteristic of the conventional design are not warranted. You will note the simply formed shapes of the suction and discharge chambers. A rather unusual feature incorporated in the pump design is the backwater closure provided to prevent the reverse flow of water under hurricane tide conditions when the pump is not in operation. The reverse flow must not be permitted to take place for it would cause reverse rotation of the pump and its motor, converting the pump into a turbine, so to speak. Starting the pump under such conditions would be difficult or even impossible. Positive means of preventing back flow in the idle pumps must be provided. The closure will normally be kept in the uppermost or fully open position and will be lowered manually into closed position when the hurricane is in the offing. It will be raised automatically when the pump is to be placed in operation by a hydraulic mechanism which must be designed to achieve accurate coordination of the upward motion of the closure with the starting characteristics of the pump and its prime mover. The raising of the closure must be rapid enough to avoid starting the pump against closed discharge and yet slow enough to prevent the establishment of excessive reverse flow.

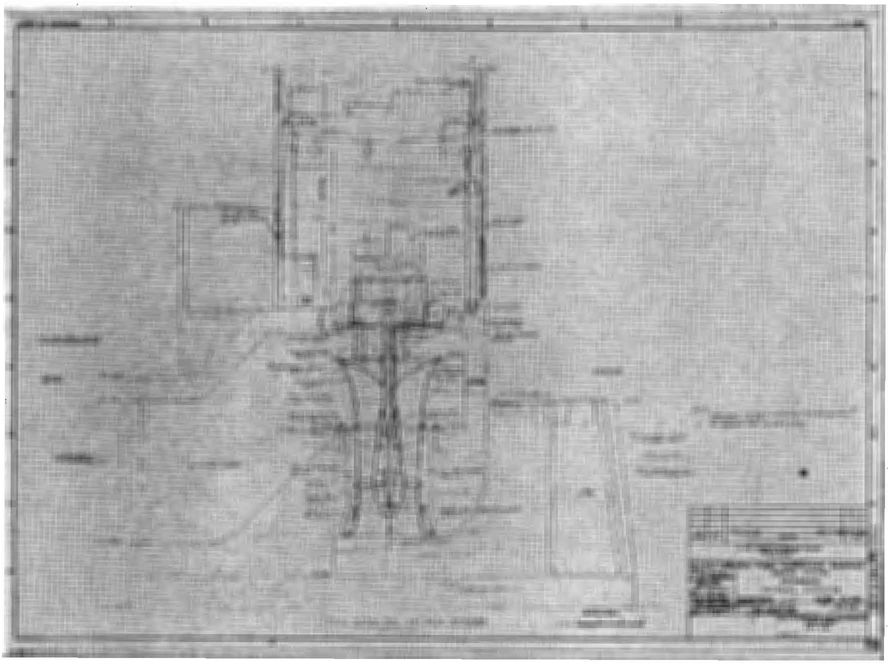


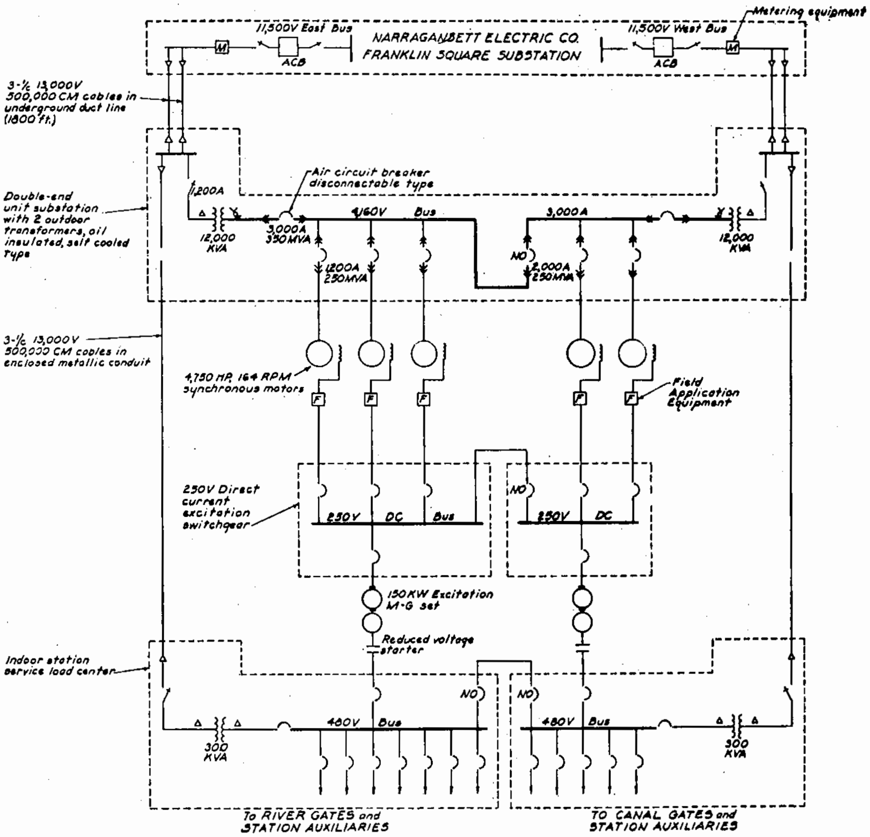
FIGURE 2.

All pump parts normally submerged in salt water, i.e., those located below the high tides—elevation 5 m.s.l.—will be manufactured of Ni-resist, a high nickle chrome alloy cast iron. This metal is virtually immune to corrosion in salt water environment and its use eliminates the necessity of costly dry sump arrangement, with its suction chamber gates, operating mechanisms and accessories.

Now a few words about the selection of prime mover for the pumps and the electrical features of the project. The electric motor is the simplest and least costly prime mover, but it is no more reliable than the electric power supply it requires. Unless the power supply possesses the attributes of absolute dependability, especially during severe storms which often raise havoc with electrical transmission and distribution lines, a self sufficient prime mover such as the internal combustion engine, should and most often is employed for driving pumps and other essential devices of flood control projects. At Fox Point we are peculiarly fortunate in this respect, for the project is situated immediately adjacent to a large and diversified electric power supply complex. The west abutment of the barrier is at the Narragansett Electric Company's plot containing the 150,000 kva Manchester Street power generating station, 120,000 kva South Street power generating station and Franklin Street substation. The substation is inter-connected with these two power plants and with the 110,000 volt transmission lines of the New England Electric system.

Thus selection of electric drive for the pumps was made possible. Each pump will be driven by a direct connected 4500 hp, 4000 volt synchronous motor. Two independent 11,000 volt underground cable circuits, approximately one quarter mile long and located in the protected area north of the west dike, will connect the pumping station with the Franklin Street substation of the Narragansett Electric Company. These two circuits will feed a double-ended substation in the pumping station, having two 12,000 kva identical transformers for stepping the supply voltage to 4160 volts which is the utilization voltage of the pump motors.

Figure 3 is a simplified one line diagram of the pumping station. Each transformer and the cable circuit feeding it is designed to have the capability of sustaining the entire operation of the pumping station in the event of failure of the other cable or transformer. These power transformers are very efficient pieces of apparatus with efficiency better than 99%. The so called no load losses amount to only two-tenths of 1%. But because of the size of these units this, what might appear to be a negligible loss, would consume, in the course of a year, some one-half million kilowatt hours without even turning a pump. Even at the favorable power rate enjoyed by the project, the cost of these losses would approximate $7,000 per year. For this reason, the transformers will normally remain deenergized until there is an indication of an approaching storm requiring the operation of the station. The station will also be activated periodically for testing the equipment. A pair of smaller transformers is provided to supply station auxiliaries, lights and other utilities.




**FOX POINT HURRICANE BARRIER**
**PUMPING STATION**
**ELECTRICAL POWER DIAGRAM**

FIGURE 3.

Figures 4 and 5 are the artist's renderings of the pumping station. The superstructure is of pink or salmon colored brick with darker brown shade used to set off the vertical panels in this windowless structure. The sizeable area of the ventilating louvers is dictated by the cooling requirements of the pump motors. To the east of the pumping station, located between the center and east barriers, are three 40 by 40 tainter gates. These will be normally kept in fully open position to permit the river flows to discharge into


FIGURE 4.

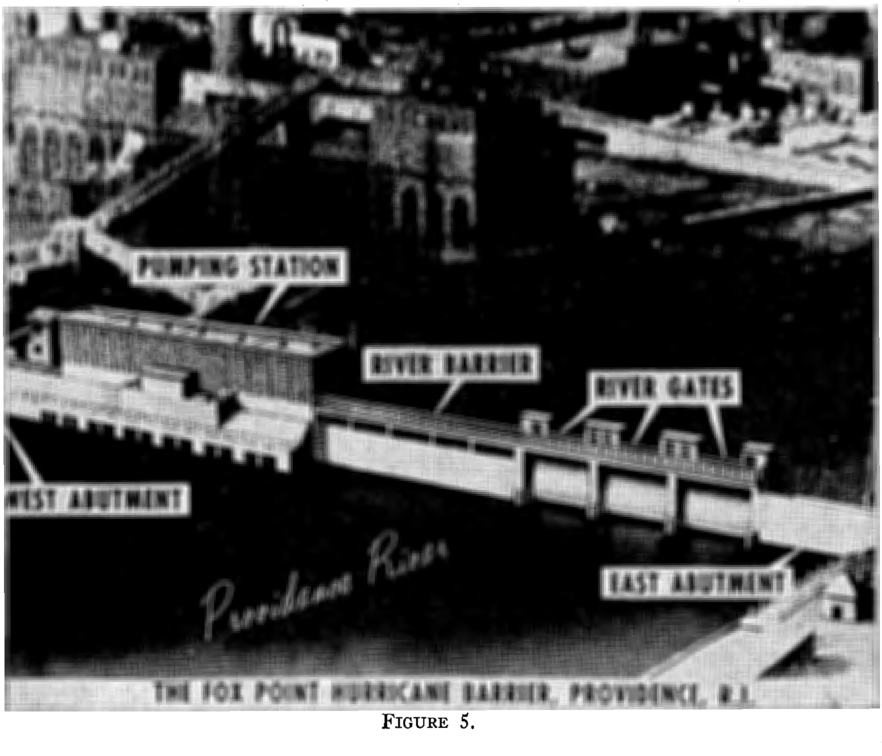



FIGURE 5.

the bay. The only navigation taking place in the river is that of coal barges and pleasure craft. Clearance of 25 feet below the fully opened gates is provided to permit this traffic. The gates are electrically operated and controlled from the pumping station. They can be lowered at the rate of one and one-half feet per minute. Full closing cycle of 40 feet would take close to one-half hour and it is expected that the gates will be partially lowered and poised in this position when a storm is anticipated so that complete closure can be effected promptly when this becomes necessary.

## ATHOLE B. EDWARDS
## 1879-1961

Mr. Athole B. Edwards, a past president of the society, died on November 29, 1961.

Mr. Edwards was born in Hemmingford, Quebec, on June 23, 1879. He attended Harvard College, and in his four years there majored in general science and economics.

From 1901 to 1917, Mr. Edwards worked on surveys for the Illinois Central Railroad and then for a short time was a salesman for a concrete products company. During World War I he was with the Ordnance Department of the U.S. Army, specializing on track layouts. For about five years, 1919 to 1924, he was city manager in St. Albans, Vermont.

It was in 1924 that Mr. Edwards started the career in which many of us remember him. On April 1 of that year he entered the employ of the Division of Metropolitan Planning as an assistant engineer. Planning was then in its infancy; the Division had been created only a year earlier, and was charged with transportation planning for the Metropolitan District, including railroads, rapid transit, air and water transportation.

Practically all of the highway and rapid transit improvements made during the life of the Division of Metropolitan Planning were recommendations of that Division. Mr. Edwards participated in many of them. To name a few: Southern Artery, Brook Farm Parkway, Concord Turnpike, East Boston Tunnel, the subway through Kenmore Square, Charles River Basin Development, and West Roxbury Parkway.

In September, 1941, the powers, duties and personnel of the Division of Metropolitan Planning were transferred to the State Planning Board. That agency was less oriented toward transportation, and Mr. Edwards' efforts were directed more to taxation and population studies. However, he never lost his interest in transportation, even after his retirement which took place on June 30, 1949. As long as he was able he appeared at every subtantial highway or construction project in Greater Boston, and he was frequently heard to say that he was the most faithful "sidewalk superintendent" in the region.

Mr. Edwards became a member of the Society in 1928, was elected a director in 1936 and president in 1942. He is kindly remembered by many of his friends in the society.

# Of General Interest

## PROCEEDINGS OF THE SOCIETY

### MINUTES OF MEETING

### Boston Society of Civil Engineers

JANUARY 24, 1962.—A regular meeting of the Boston Society of Civil Engineers was held this evening in the Society Rooms, 20 Pemberton Square, Boston, Mass., and was called to order by Vice President Charles H. Norris, at 7:00 P.M.

Vice President Norris stated that the minutes of the previous meeting held December 13, 1961 would be published in a forthcoming issue of the Journal and that the reading of those minutes would be waived unless there was objection.

Vice President Norris announced the death of the following members:—

Harold C. Whitemore, who was elected a member May 19, 1915, and who died December 29, 1961.

John P. Wentworth, who was elected a member January 24, 1912, and who died January 20, 1962.

Arthur J. Ober, who was elected a member March 20, 1895, and who died January 21, 1962.

Frederick T. Weed, who was elected a member May 17, 1948, and who died January 23, 1962.

The Secretary announced the names of applicants for membership in the Society and that the following had been elected to membership January 22, 1962:—

*Grade of Member*—George W. Fait, Henry D. Hoyle, Jr.

Vice President Norris requested the Secretary to present a recommendation of the Board of Government to the Society for action and 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 15, 1962.

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

> MOTION "to recommend to the Society that the Board of Government be authorized to transfer an amount not to exceed $2500 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 $2500 from the Principal of the Permanent Fund to the Current Fund for current expenditures."

Vice President Norris stated that final action on this matter would be taken at the February 21, 1962 meeting of the Society.

Vice President Norris then introduced the speaker of the evening, Mr. Richard R. Green, Project Director of Parker Hill Fenway Project, Boston Redevelopment Comm., who gave a most interesting talk on "Progress of Redevelopment Program." Following the talk was a discussion and question period.

30 members and guests attended the meeting.

The meeting adjourned at 9:00 P.M.

CHARLES O. BAIRD, JR., *Secretary*

FEBRUARY 21, 1962.—A Joint Meeting of the Boston Society of Civil Engineers with the Hydraulics and Structural Sections was held this evening at the United Community Services Building, 14 Somerset Street, Boston, Mass., and was called to order by President James F. Brittain, at 7:00 P.M.

President Brittain stated that the minutes of the previous meeting held January 24, 1962 would be published in a forthcoming issue of the Journal and that the reading of those minutes would be waived unless there was objection.

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

President Brittain requested the Secretary to present a recommendation of the Board of Government to the Society for action, and 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 February 12, 1962.

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

> MOTION "to recommend to the Society that the Board of Government be authorized to transfer an amount not to exceed $2500 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 $2500 from the Principal of the Permanent Fund to the Current Fund for current expenditures."

President Brittain stated that this was the final action on this matter.

President Brittain stated that this was a Joint Meeting with the Hydraulics and Structural Sections and called upon Donald R. F. Harleman, Chairman of the Hydraulics Section and Myle J. Holley, Jr., Chairman of the Structural Section to conduct any necessary business of those Sections at this time.

President Brittain introduced speaker of the evening, Howard M. Turner, Consulting Engineer, who presented a most interesting illustrated talk on "New England Floods and the Society's Flood Reports." Following the talk was a discussion period.

Forty-two members and guests attended the dinner preceding the meeting and 66 members and guests attended the meeting.

The meeting adjourned at 8:45 P.M.

CHARLES O. BAIRD, JR., *Secretary*

MARCH 22, 1962.—The 114th Annual Meeting of the Boston Society of Civil Engineers was held today at the M.I.T. Faculty Club, Cambridge, Mass., and was called to order at 4:00 P.M., by President James F. Brittain.

President Brittain 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 would be published in a forthcoming issue of the Journal. The Minutes of the April, May, September, October, November and December 1961 meetings to be declared approved as published.

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

The Secretary announced the names of applicants for membership in the Society and that the folowing had been elected to membership on March 19, 1962:—

> *Grade of Member*—John P. LeBlanc, Charles H. Mitchell*, William Simonson.

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*Transfer from Junior

*Grade of Junior*—Warren D. McLea, Domenic V. Tutela.

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, Public Relations, Advertising, Subsoils of Boston and Joint Legislative Committee.

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

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

President Brittain stated that all foregoing reports would be published in the April, 1962 issue of the Journal.

The Report of the Tellers of Election, Marcello J. Guarino and Benedict J. Quirk was presented and in accordance therewith the President declared the following had been elected officers for the ensuing year:—

President George G. Bogren
V-President (for one year) John F. Flaherty
V-President (for two years) William A. Henderson
Secretary (for one year) Charles O. Baird, Jr.
Treasurer (for one year) Paul A. Dunkerley
Directors (for two years) Clair N. Sawyer, Paul S. Crandall
Nominating Committee (for two years) James W. Daily, Richard W. Albrecht, Roy L. Wooldridge

The retiring President James F. Brittain then gave his address entitled "Our Profession and Our Society—Then and Now."

Forty members and guests attended the business meeting.

The meeting adjourned at 5:20 P.M. to re-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 George G. Bogren, and other guests at the head table the various prize awards were made.

The Secretary read the various prize awards and asked the recipients to come forward and President Brittain presented the following awards:

| *Award* | *Recipient* | *Paper* |
|---|---|---|
| Desmond FitzGerald Medal | Gordon M. Fair | "Publish or Perish—The Survival of Civil Engineering as a Learned Profession". |
| Clemens Herschel Awards | Hon. John F. Collins | "Rebuilding a City". |
| | R. Steven Kleinschmidt | "Hydraulic Design of Detention Tank". |
| Sanitary Section Award | Ariel A. Thomas | "Starting New Sewage Treatment Plants". |
| Structural Section Award | William H. Mueser | "The Carrier Repair Site—Puget Sound Naval Shipyard". |
| Hydraulics Section Award | Howard M. Turner | "Report of the Boston Society of Civil Engineers' Flood Committee". |
| Desmond FitzGerald Scholarship | Marcia A. Bush | Northeastern University |
| William P. Morse Scholarship | Robert J. Merlino | Tufts University |

President Brittain introduced the guest speaker of the evening, Prof. George H. Meserve, Jr., Chairman, Art Department, Northeastern University who gave a most interesting illustrated talk on "Engineering in Ancient Architecture".

At the conclusion of the talk President Brittain turned the meeting over to President elect George G. Bogren.

President Bogren presented retiring President James F. Brittain with a certificate of appreciation for services rendered.

The meeting adjourned at 10:30 P.M. One hundred fifty-nine members and guests attended the dinner and meeting.

CHARLES O. BAIRD, JR., *Secretary*

## STRUCTURAL SECTION

JANUARY 10, 1962.—The meeting was opened by Chairman Myle J. Holley, Jr., who introduced the speaker, Robert J. Hansen, Professor of Structural Engineering, Massachusetts Institute of Technology. Professor Hansen spoke on the "Feasibility of Structural Hardening against Nuclear Weapons." Professor Hansen has been doing research on the effects of blast on structures since World War II, and has been intimately involved in committee work on protection against nuclear warfare. He was a member of the Gaither Committee, he is consultant to the Air Force, Department of Defense, and a member of the firm of Newmark Hansen and Associates which is currently doing research on these problems.

The main purpose of his talk was to correct misleading impressions that there is little or no protection against the effects of nuclear warfare, or that such protection is uneconomical. This thinking results partly from an emotional approach to the problem, partly from the appalling magnitude of the problem when considered as a whole. Professor Hansen broke the problem up into six components: shock effects, nuclear radiation, thermal radiation, fallout, ground shock and firestorm. He showed slides showing the results of research on each of these phases, and told his audience that information has been and is being made available to architects and engineers on public and private shelters.

His contention is that "provision for survival from all effects of nuclear weapons is technically feasible up to the crater lip," and that anyone can provide some measure of protection.

The talk of about an hour's length was followed by very lively discussion for another hour. The attendance was about 45.

P. S. RICE, *Clerk*

## SURVEYING AND MAPPING SECTION

JANUARY 17, 1962.—The regular annual meeting of the Surveying and Mapping section of the Boston Society of Civil Engineers was called to order by Roy L. Wooldridge at 7:05 P.M., at the Society Rooms on this date. Due to the absence of the Clerk, the reading of the report of the last meeting was omitted.

Mr. Harry R. Feldman, Chairman of the Nominating Committee, presented the following slate of officers for the coming year, and they were duly elected by the members present.

| | |
|---|---|
| Chairman | Richard D. Raskind |
| Vice-Chairman | Rudolf S. Slayter |
| Clerk | Joseph E. Bodio |

Executive Committee

Robert E. Cameron
Alexander E. Manning
John P. Hurney

Since there was no further business to be discussed on this occasion, the Chairman introduced the speakers of the evening, Philip H. Kitfield, Chief Engineer—Massachusetts Turnpike Authority, James A. Armstrong, Resident Engineer—Massachusetts Turnpike Authority, Edward J. Cameron, Field Engineer—New England Survey Service, who spoke on the subject "The William F. Callahan, Jr., Tunnel". Mr. Comeau's part of the talk was accompanied by some interesting slides taken at the construction site. After a question and answer period, the meeting was adjourned at 9:00 P.M.

The meeting was attended by fifty members and guests.

ROY L. WOOLDRIDGE, *Acting Clerk*

## ADDITIONS

*Members*

David W. Beach, P.O. Box 116, Woodstock, Conn.

LeRoy E. Christie, 470 Lebanon Street, Melrose, 76, Mass.

John R. Elwood, 83 Karen Road, Framingham, Mass.

George W. Fait, 70 Common Street, Quincy 69, Mass.

Sepp Firnkas, 120 Boylston Street, Boston, Mass.

William S. Hartley, 321 Lincoln Street, Waltham 54, Mass.

Henry D. Hoyle, 126 Summer Avenue, Reading, Mass.

Bradford H. Jones, 65 Belmont Street, Weymouth, Mass.

William Simonson, 44 Revere Beach Pky., Revere 51, Mass.

*Juniors*

Domenic V. Tutela, 86 Fellsway West, Somerville, Mass.

*Deaths*

Harold C. Whitemore, Dec. 29, 1961

# ANNUAL REPORTS

## REPORT OF THE BOARD OF GOVERNMENT FOR YEAR 1961-1962

Boston, Mass., March 22, 1962

*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 22, 1962.

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

| | |
|---|---|
| Honorary | 7 |
| Members | 992 |
| Associates | 6 |
| Juniors | 49 |
| Students | 1 |
| Total | 1055 |
| Student Chapters | 2 |

*Summary of Additions*

| | |
|---|---|
| New Members | 25 |
| New Juniors | 7 |

*Reinstatements*

| | |
|---|---|
| Members | 7 |

*Summary of Transfers*

| | |
|---|---|
| Junior to Member | 14 |

*Summary of Loss of Members*

| | |
|---|---|
| Deaths | 13 |
| Resignations | 8 |
| Dropped for non-payment of dues | 22 |
| Dropped for failure to transfer | 10 |

| | |
|---|---|
| Life Members | 99 |
| Members becoming eligible today for Life Membership | 9 |
| Applications pending on March 22, 1962 | 11 |

*Honorary Membership is as follows*:

Frank M. Gunby, elected, February 15, 1950
Karl R. Kennison, elected, February 7, 1951

Frank A. Marston, elected, February 15, 1960
Charles M. Spofford, elected, December 19, 1945
Howard M. Turner, elected, February 18, 1952
William F. Uhl, elected, February 7, 1955
Karl Terzaghi, elected, March 3, 1952

*The following members have been lost through death*:

Wilbur S. Colby, Sept. 17, 1961
Alfred Colletti, June 20, 1960
Athole B. Edwards, Nov. 29, 1961
Hugh P. Duffill, Sept. 22, 1961
Albert E. Lochridge, Oct. 3, 1961
John C. Moses, Oct. 26, 1961
Charles E. Newcomb, May 1, 1961
Arthur J. Ober, Jan. 21, 1962
Grant H. Potter, Apr. 15, 1961
Walter J. Reed, Apr. 21, 1961
Frederick T. Weed, Jan. 23, 1962
Harold C. Whitemore, Dec. 29, 1961
John P. Wentworth, Jan. 20, 1962

*Meetings of the Society*

*March 16, 1961.* Address of the retiring President, Arthur T. Ippen. "Water Resources Development. A Vital Responsibility of the Civil Engineer."

*April 12, 1961.* Joint Meeting with Structural and Construction Sections. "Design and Construction of Bremerton Base Drydock, Carrier Repair Site—Puget Sound Naval Shipyard." William H. Mueser of firm Moran, Proctor, Mueser and Rutledge, and Capt. Perry Boothe, C.E.C., U.S. Navy.

*May 17, 1961.* Joint Meeting with Surveying & Mapping Section. "The Survey for the Cambridge Electron Accelerator." Dr. David D. Jacobus, Senior Mechanical Engineer, Harvard University.

*September 27, 1961.* "Investigations and Studies for the Richmond Water Tunnel under New York Harbor." Stanley M. Dore, Chief Engineer, Board of Water Supply, City of New York.

*October 25, 1961.* Joint Meeting with Mass. Section, ASCE. Student Night. "The Opportunity for Junior Professional Personnel in the Peace Corps." Thomas H. E. Quimby, Director of Recruitment Peace Corps, Washington, D.C.

*November 15, 1961.* "Trends in Engineering Education." Prof. Earle F. Littleton, Head of Department of Civil Engineering, Tufts University.

*December 13, 1961.* Joint Meeting with the Structural Section. "The Fox Point Flood Hurricane Carrier, Providence, R. I." John W. Leslie, Chief Engrg. Div. N.E. Corps of Engrs.; Herbert Whittemore and Eugene Groden, N.E. Corps of Engineers.

*January 24, 1962.* "Progress of Redevolpment Program." Richard R. Green, Project Director of Parker Hill Fenway Project.

*February 21, 1962.* "New England Floods and the Society's Flood Reports." Howard M. Turner, Consulting Engineer.

*Attendance at Meetings*

| *Date* | *Place* | *Meeting* | *Dinner* |
|---|---|---|---|
| March 16, 1961 | M.I.T. Faculty Club | 35 | 160 |
| April 12, 1961 | United Community Services Building | 65 | 50 |
| May 17, 1961 | United Community Services Building | 18 | |
| September 27, 1961 | United Community Services Building | 55 | 70 |
| October 25, 1961 | Mass. Inst. Technology | 110 | 110 |
| November 15, 1961 | United Community Services Building | 24 | |
| December 13, 1961 | United Community Services Building | 90 | 65 |
| January 24, 1962 | Society Rooms | 30 | |
| February 21, 1962 | United Community Services Building | 66 | 42 |

Average Attendance 70

*Sections*

Twenty-one 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. The Annual Report of the various Sections will be presented at the Annual Meeting and published in the April 1962 issue of the Journal.

*Funds of the Society**

*Permanent Fund.* The Permanent Fund of the Society has a present value of $66,973.66. The Board of Government authorized the use of as much as necessary 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 24, 1962 and February 21, 1962 meetings, the Board of Government was authorized to transfer an amount not to exceed $2500 from the Principal of the Permanent Fund for current expenditures. No transfer from the Principal of the Permanent Fund was necessary for current expenditures this year.

*John R. Freeman Fund.* In 1955 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

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

open to members of the Society for visiting engineering works, a report of which would be presented to the Society. The expenditure from this fund during the year, approved by the Committee, was payment of preparation and publication of the Flood Committee Report amounting to $2217.92.

*Edmund K. Turner Fund.* In 1916 the Society received 1,105 books from the library of the late Edmund K. Turner, a former member of the Society, and a bequest of $1,000, "the income of which is to be used for library purposes." The Board voted to use $80 of the income for the purchase of books for the library. The expenditure from this fund during the year was $76.70.

*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 $80 of the available income for the purchase of books for the Library. The expenditure from this fund during the year was $76.70.

*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 Engineering, had a value of $2,338.16 on June 30, 1961. John R. Brach, a student in Civil Engineering, class of 1963 was awarded this Scholarship of $200 for year 1961-62.

*Desmond FitzGerald Fund.* The Desmond FitzGerald 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 vote on April 11, 1960 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 Civil Engineering student at Northeastern University. It was VOTED February 13, 1961 "to adopt the recommendation of the Committee at Northeastern University, namely, a $100 Scholarship be given to Joseph H. Metelski. Presentation was made at the Annual Meeting of the Society March 16, 1961.

*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 11, 1961 that payment of Prize Awards be appropriated from the income of this fund. The expenditure made during the year from the income of this fund was $66.14.

*Edward W. Howe Fund.* This fund, a bequest of $1,000 was received in 1933 from the late Edward W. Howe, a former Past President of the Society. No restrictions were placed upon the use of this money, but the recommendation of the Board of Government was that the fund be kept intact, and that the income be used "for the benefit of the Society or its members." The Board voted April 11, 1961 that no appropriation be made from this fund.

*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 recommendations of the Board of Government was "that this 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 4, 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 Civil Engineering student at Tufts University." It was VOTED February 13, 1961 a $100 Scholarship be given to John C. LeFevre. Presentation was made at the Annual Meeting of the Society March 16, 1961.

*Prizes*

| *Award* | *Recipient* | *Paper* |
|---|---|---|
| Desmond Fitz-Gerald Medal | Gordon M. Fair | "Publish or Perish—The Survival of Civil Engineering as a Learned Profession." |
| Clemens Herschel Awards | Hon. John F. Collins | "Rebuilding an Old City." |
| | R. Steven Kleinschmidt | "Hydraulic Design of Detention Tank." |
| Sanitary Section Award | Ariel A. Thomas | "Starting New Sewage Treatment Plants." |
| Structural Section Award | William H. Mueser | "The Carrier Repair Site—Puget Sound Naval Shipyard." |
| Hydraulics Section Award | Howard M. Turner | "Report of BSCE Committee on Floods." |

*Library*

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

*Committees*

The 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 the Committees will be presented at the Annual Meeting.

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.

JAMES F. BRITTAIN, *President*

## REPORT OF THE TREASURER

Boston, Mass., March 22, 1962

*To the Boston Society of Civil Engineers*:

This report is for the year beginning March 1, 1961 and terminating at the close of business on March 1, 1962.

As in recent years our investment securities are held by the Boston Safe Deposit and Trust Company which serves as custodian and as investment counsel. Any transactions of securities which have been made during the year were accomplished after a vote of approval by the Board of Government of the Society acting upon the recommendations made by the Boston Safe Deposit and Trust Company. At the close of the fiscal year the Boston Safe Deposit and Trust Company furnishes the Treasurer of the Boston Society of Civil Engineers with a certified copy of an audit of the account made by the auditors of the bank.

The financial standing of the Society as of March 1, 1962, are summarized in seven of the tables accompanying this report. These seven tables are as follows:

| | | |
|---|---|---|
| Table | I | Comparison of Book Values and Market Values of Stocks, Bonds, Co-op Bank, and Investment Cash. |
| Table | II | Comparison of Book and Market Value of Funds. |
| Table | III | Distribution of Funds—Receipts and Expenditures. |
| Table | IV | Distribution of Funds—Receipts and Expenditures. |
| Table | V | Record of Investments—Bonds. |
| Table | VI | Record of Investments—Stocks. |
| Table | VII | Record of Investments—Savings Bank (Formerly Co-operative Bank Account). |

Three tables have been prepared to compare the Book Value, the Market Value, and the earnings from our holdings during the past six years. These tables are as follows:

| | | |
|---|---|---|
| Table | VIII | Comparison of Book Values During Last Six Years. |
| Table | IX | Comparison of Market Values During Last Six Years. |
| Table | X | Comparison of Earnings from Invested Fund During Last Six Years. |

(NOTE: In Table II the funds listed Boring Data, Vol. I, and Sanitary Lectures are actually in the form of cash or publications available for sale and were considered to have the same Book Value and Market Value.)

During the fiscal year the following changes in securities were accomplished by the Boston Safe Deposit and Trust Company:

American Telephone and Telegraph Co.
Sold 207 Rights

Pacific Gas and Electric Co.
Sold 105 Rights

Received 210 shares in stock split
Total Increase 210 shares

Texaco, Inc.
Received 222 shares in stock split
Total Increase 222 shares

Southern California Edison Co.
Received 80 shares of preferred in stock split
Received 118 shares of common in stock split

Scott Paper Co.
Delivered $1000 Convertible Debenture Bond for conversion
Received 38 shares of common in conversion
Received 150 shares of common in stock split
Total increase 188 shares

Early in the fiscal year the series of lectures sponsored by the Sanitary Section were prepared for publication. The Board of Government authorized the publication of the lectures on the basis of approval given by the Society at the April and May meetings in 1959. Cash from the Permanent Fund was employed to accomplish the desired purpose and a new fund established as indicated in Table IV. This fund is designated by a negative sum which approaches zero as the publications are sold. As has been the custom the price of these publications has been held to a minimum so that the sale price does not exceed printing and distribution costs.

The report of "Boring Data from Greater Boston" was made ready for publication during the year. In November 1958, by vote of the Board of Government, a fund of $1000 was established to meet the publication costs of this report. When the report was ready it was published with this fund.

The Flood Committee has worked arduously since September 1955 compiling and analyzing data on the great floods of August 1955 and October 1955. Their work was completed this year. The income to the Freeman Fund was used to publish the report in the second section of the October 1961 issue of the Journal of the Boston Society of Civil Engineers. This report is an outstanding contribution to the Profession of Civil Engineering in that it provides a better basis for the design of Engineering Projects dealing with precipitation and runoff.

The income to the Permanent Fund from dividends and interest less the expenses charged to the Permanent Fund amounted to $3,900.75. From this income it was necessary to transfer $3,536.55 to meet current expenses. The difference in these two amounts plus the $355.00 received in Entrance Fees increased the Book Value of the Permanent Fund by $719.20.

In May of 1961, the Secretary received a check of $1000 from the estate of the late Mary H. Walker given in memory of her husband, Past President Frank B. Walker. It was voted by the Board of Government at the May meeting to use the $1000 to establish a fund to be known as the Frank B. Walker Fund. No restriction was placed on the use of the money, but that the income would be utilized for the benefit of the Society and its members.

Of the cash funds on hand as indicated by the following tables, $316.93 is held in escrow for Federal Withholding Tax, Massachusetts Income Tax, and Social Security payments.

PAUL A. DUNKERLEY, *Treasurer*

TABLE I
COMPARISON OF BOOK VALUES AND MARKET VALUES OF STOCKS, BONDS, CO-OP BANK, AND INVESTMENT CASH

| | Book Value Mar. 1, 1962 | Market Value Mar. 1, 1962 |
|---|---|---|
| Bonds | 50,818.46 | 45,747.51 |
| Stocks | 55,960.99 | 177,346.88 |
| Co-op Bank | 4,616.55 | 4,616.55 |
| Available for Investment | 1,998.10 | 1,998.10 |
| Total 1962 | 113,394.10 | 229,709.04 |
| Total 1961 | 114,670.25 | 205,230.31 |
| Increase or Decrease | —1,276.15 | 24,478.73 |

TABLE II
COMPARISON OF BOOK AND MARKET VALUES OF FUNDS

| | Book Values | Market Value |
|---|---|---|
| Permanent | 66,973.66 | 134,965.12 |
| John F. Freeman | 35,306.64 | 71,149.83 |
| Edmund K. Turner | 1,328.64 | 2,677.47 |
| Desmond FitzGerald | 2,462.76 | 4,962.95 |
| Alexis H. French | 1,317.46 | 2,654.94 |
| Clemens Herschel | 1,167.21 | 2,352.16 |
| Edward W. Howe | 1,266.42 | 2,552.09 |
| William P. Morse | 2,517.80 | 5,073.86 |
| Surveying Lectures | 543.71 | 1,095.68 |
| Structural Lectures | 392.65 | 791.27 |
| Boring Data* | 90.50 | 90.50 |
| Vol. I* | 1,224.69 | 1,224.69 |
| Transportation Lectures | 249.27 | 502.33 |
| Frank B. Walker | 1,047.54 | 2,111.00 |
| Sanitary Lectures* | —2,494.85 | —2,494.85 |
| Sub total | 113,394.10 | 229,709.04 |
| Current Fund | 1,500.00 | 1,500.00 |
| Total | 114,894.10 | 231,209.04 |

* These funds are not interest earning invested funds, but are cash assets or publications representing a cash outlay.

Table III

Distribution of Funds—Receipts and Expenditures

BOSTON SOCIETY OF CIVIL ENGINEERS

Report of Treasurer Mar. 1, 1962

| | Distribution of Funds | | | Receipts anc | | |
|---|---|---|---|---|---|---|
| | | | | Net Profit or Loss at Sale or Maturity | | Trai Purcha |
| | Book Value Mar. 1, 1961 | Interest and Dividends Cash | Credit | + | — | + |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Bonds | 51,942.25 | 1,907.50 | | | | |
| Co-op Bank | 4,442.74 | | 173.81 | | | |
| Stocks | 55,193.47 | 5,259.55 | | | | 1,083. |
| Available for Investment | 3,091.79 | | | | | |
| | 114,670.25 | 7,167.05 | 173.81 | | | 1,083. |

Columns 1 + 3 + 6 — 7 = 8

## Table IV

### Distribution of Funds—Receipts and Expenditures
### BOSTON SOCIETY OF CIVIL ENGINEERS
### Report of Treasurer—March 1, 1962

| Funds | Book Value March 1, 1961 | Allocation of Income-Profit and Loss — Income Col. 2 & 3 | Net Profit Col. 4 & 5 | Recei |
|---|---|---|---|---|
| Permanent | $ 66,254.40 | $ 4,297.52 | | 355 |
| John R. Freeman | 35,454.25 | 2,288.11 | | |
| Edmund K. Turner | 1,327.32 | 85.95 | | |
| Desmond FitzGerald | 2,478.74 | 154.29 | | |
| Alexis H. French | 1,331.91 | 86.21 | | |
| Clemens Herschel | 1,167.17 | 72.96 | | |
| Edward W. Howe | 1,196.10 | 77.47 | | |
| William P. Morse | 2,476.96 | 155.34 | | |
| Surveying Lectures | 513.53 | 33.26 | | |
| Structural Lectures | 370.85 | 24.02 | | |
| Boring Data | 1,000.00 | 0.00 | | 555 |
| Vol. I | 863.57 | 0.00 | | 451 |
| Transportation Lectures | 235.45 | 15.23 | | |
| Frank B. Walker | 0.00 | 50.50 | | 1,000 |
| Sanitary Lectures | 0.00 | 0.00 | | 634 |
| Sub total | $114,670.25 | $ 7,340.86 | | $ 2,996 |
| Current | 1,500.00 | 3,536.55** | | 17,247 |
| Totals | $116,170.25 | $10,877.41 | | $20,243 |

Secretary's change fund of $30.00 should be added to show tota

| Cash Balance | |
|---|---|
| Investment Fund | $1,998.10 |
| Current Fund | 1,500.00 |
| Total Cash | $3,498.10 |

| | |
|---|---|
| * $3,536.55 | Transferr |
| ** 3,536.55 | Transferr |
| 0.00 | Transferr |

## Table V

### Record of Investments—Bonds
### March 1, 1961 to March 1, 1962

| Bonds | Date of Maturity | Interest Rate | Interest Received | |
|---|---|---|---|---|
| Aluminum Company of America | Apr. 1, 1983 | 3⅞% | $ 193.75 | $ |
| Associates Investment Co. Deb. | Aug. 1, 1979 | 5⅛% | 307.50 | |
| Columbia Gas System Inc., Deb., Series D | July 1, 1979 | 3½% | 70.00 | |
| Consumers Power Co. 1st Mortgage | Sept. 1, 1975 | 2⅞% | 86.25 | |
| Florida Power Co. 1st Mortgage | July 1, 1984 | 3⅛% | 31.25 | |
| Florida Power Co. 1st Mortgage | July 1, 1986 | 3⅞% | 193.75 | |
| General Motors Acceptance Corp. | Sept. 1, 1975 | 3⅝% | 181.25 | |
| Georgia Power Co. 1st Mortgage | Dec. 1, 1977 | 3⅜% | 168.75 | |
| Province of Ontario | Sept. 1, 1972 | 3¼% | 97.50 | |
| Public Service Electric and Gas Co. | June 1, 1979 | 2⅞% | 115.00 | |
| Scott Paper Co. Conv. Deb.[1] | Mar. 1, 1971 | 3.0% | 15.00 | |
| So. Pacific 1st Series A Oregon Lines | Mar. 1, 1977 | 4½% | 180.00 | |
| Superior Oil Co., Deb. | July 1, 1981 | 3¾% | 150.00 | |
| Tidewater Oil Co., Deb. | Apr. 1, 1986 | 3½% | 70.00 | |
| U.S.A. Treasury Notes, Series A | May 15, 1964 | 4¾% | 47.50 | |
| Totals | | | $1,907.50 | $5 |

[1] Converted to 38 shares of Common Stock plus $40.61 in lieu of a fractional share on D

TABLE VI

RECORD OF INVESTMENTS—STOCKS

MARCH 1, 1961 TO MARCH 1, 1962

| Stocks | Classification | Number of Shares | Divide Receiv |
|---|---|---|---|
| American Telephone and Telegraph Co. | Common | 207 | $ 729.6 |
| Consolidated Edison of New York, Inc. | Common | 50 | 150.0 |
| Continental Insurance Co. | Common | 150 | 330.0 |
| General Electric Co. | Common | 150 | 300.0 |
| Hartford Fire Insurance | Common | 104 | 114.4 |
| General Motors Corp. | Common | 126 | 315.0 |
| Jewel Tea Co. | Common | 62 | 96.1 |
| National Dairy Products Corp. | Common | 100 | 200.0 |
| New England Electric System | Common | 198 | 215.8 |
| Pacific Gas and Electric Co. | Common | 315 | 294.0 |
| Scott Paper Co. | Common | 263 | 168.7 |
| Southern California Edison Co. | Common | 177 | 153.4 |
| Standard Oil of New Jersey | Common | 324 | 745.2 |
| Texaco, Inc. | Common | 444 | 688.2 |
| Union Carbide Corp. | Common | 100 | 360.0 |
| Pacific Gas and Electric Co. | Preferred | 100 | 150.0 |
| Radio Corporation of America | Preferred | 20 | 70.0 |
| Southern California Edison Co., Ltd. | Preferred | 120 | 104.0 |
| Southern Railway Co. | Preferred | 75 | 75.0 |
| Totals | | | $5,259.5 |

TABLE VII

RECORD OF INVESTMENTS—SAVINGS BANK

| Savings Bank | Classification | Interest Received | Bo Ma |
|---|---|---|---|
| First Federal Savings and Loan Association of Boston, Acct. No. 1S-631 | Savings Account | $173.81 | $ |

### Table VIII
#### Comparison of Book Values During Last Six Year

| Year | 1957 | 1958 | 1959 | 1960 |
|---|---|---|---|---|
| Bonds | $ 51,907.25 | $ 51,907.25 | $ 52,944.75 | $ 51,942.25 |
| Stocks | 51,465.51 | 51,432.25 | 52,026.74 | 52,108.32 |
| Savings Bank | 4,845.16 | 5,003.89 | 4,155.11 | 4,291.23 |
| Available for Investment | 4,388.24 | 1,212.35 | 1,208.18 | 725.74 |
| Totals | $112,606.16 | $109,555.74 | $110,334.78 | $109,067.54 |

### Table IX
#### Comparison of Market Values During Last Six Yea

| Year | 1957 | 1958 | 1959 | 1960 |
|---|---|---|---|---|
| Bonds | $ 48,531.24 | $ 48,956.90 | $ 47,671.60 | $ 44,690.65 |
| Stocks | 109,725.00 | 106,907.46 | 135,493.75 | 133,957.52 |
| Savings Bank | 4,845.16 | 5,003.89 | 4,155.11 | 4,291.23 |
| Available for Investment | 4,388.24 | 1,212.35 | 1,208.18 | 725.74 |
| Totals | $167,489.64 | $162,080.60 | $188,528.64 | $183,665.14 |

### Table X
#### Comparison of Earnings from Invested Fund During Last

| Year | 1957 | 1958 | 1959 | 1960 |
|---|---|---|---|---|
| Bonds | $1,379.03 | $1,691.95 | $1,738.85 | $2,133.52 |
| Savings Bank | 162.92 | 158.73 | 151.22 | 136.12 |
| Stocks | 4,413.45 | 4,647.80 | 4,708.05 | 5,000.46 |
| Totals | $5,955.40 | $6,498.48 | $6,598.12 | $7,270.10 |

## REPORT OF THE SECRETARY

Boston, Mass., March 22, 1962

*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 22, 1962

| | Expenditures | Receipts |
|---|---|---|
| *Office* | | |
| Secretary, salary & expense | $ 749.76 | |
| Treasurer's Honorarium | 399.88 | |
| Stationery printing & postage | 769.41 | |
| Incidentals & Petty Cash | 106.16 | |
| Insurance & Treasurer's Bond | 23.56 | |
| Quarters, Rent, Tel. | 3,957.99 | |
| Office Secretary | 5,083.44 | |
| Social Security | 201.02 | |
| *Meetings* | | |
| Rent of Halls, etc. | 280.00 | |
| Stationery, printing & postage | 60.00 | |
| Hospitality Committee | 1,156.95 | $ 1,048.17 |
| Reporting & Projection | 34.00 | |
| Annual Meeting, March 1961 | 638.80 | 567.50 |
| *Sections* | | |
| Sanitary Section | 18.60 | |
| Structural Section | 36.00 | |
| Transportation Section | 8.00 | |
| Hydraulics Section | 8.83 | |
| Construction Section | 20.80 | |
| Surveying & Mapping Section | 46.48 | |
| *Journal* | | |
| Editor's salary & expense | 749.76 | |
| Printing & Postage | 4,890.62 | |
| Advertisement | — | 1,997.00 |
| Sale of Journals & Reprints | — | 2,078.38 |
| Copyright | 16.00 | |
| *Library* | | |
| Periodicals | 85.50 | |
| Binding | 112.50 | |
| Forward | $19,454.06 | $ 5,691.05 |

REPORT OF THE SECRETARY (Continued)

| | Expenditures | Receipts |
|---|---|---|
| Brought Forward | $19,454.06 | $ 5,691.05 |
| *Miscellaneous* | | |
| Binding Journals for Members | 9.00 | 4.50 |
| Badges | — | 9.00 |
| Bank Charges | 2.32 | — |
| Miscellaneous | 224.05 | 9.50 |
| Engineering Societies Dues and charge for Journal space | 1,064.73 | |
| Public Relations Committee | 29.94 | |
| Membership Committee | — | |
| Dues from B.S.C.E. Members | | 11,533.50 |
| Trans. Income Perm Fund | | 3,536.55 |
| | $20,784.10 | $20,784.10 |

Entrance Fees to Permanent Fund $355.00

25 New Members; 7 New Junior Members; 14 Juniors transferred to Member.

The above receipts have been paid to the Treasurer who's receipt the Secretary holds. The Secretary holds cash amounting to $30 included as payment under item 25 (Petty Cash) to be used as a fixed fund or cash on hand. $232.13 withholding tax and $84.80 Social Security which is payable to Collector of Internal Revenue and State of Massachusetts in April, 1962 is not included in the above tabulation.

CHARLES O. BAIRD, JR., *Secretary*

## REPORT OF THE AUDITING COMMITTEE

Boston, Mass., March 22, 1962

*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.

WILLIAM A. HENDERSON
HARRY L. KINSEL

## REPORT OF THE EDITOR

Boston, Mass., March 19, 1962

*To the Board of Government*
*Boston Society of Civil Engineers*

The Journal was issued quarterly, in the months of April, July and October 1961 and anuary, 1962, as authorized by the Board of Government on December 20, 1935.

During the year there have been published 16 papers and 17 discussions presented at meetings of the Society and Sections.

The four issues of the Journal contained 339 pages of papers and proceedings, 8 pages of Index and 39 pages of advertising, a total of 386 pages. An average of 1650 copies per issue were printed.

The cost of printing the Journal was as follows:

*Expenditures*

| | |
|---|---|
| Composition and printing | $3,905.25 |
| Cuts | 656.12 |
| Wrapping, mailing & postage | 329.25 |
| Editor | 749.76 |
| Copyright | 16.00 |
| | $5,656.38 |

*Receipts*

| | |
|---|---|
| Receipts from sale of Journal and reprints | $2,078.38 |
| Receipts from Advertising | 1,997.00 |
| | $4,075.38 |
| Net cost of Journal to be paid from Current Fund | $1,581.00 |

CHARLES E. KNOX, *Editor*

## REPORT OF THE LIBRARY COMMITTEE

Boston, Mass., March 8, 1962

*To the Boston Society of Civil Engineers:*

The work of the Library Committee consisted of the selection of new books to be purchased for the library. To this end recommendations were solicited from the Chairmen of the various Sections, and these were reviewed at a committee meeting on December 28, 1961.

Along with these and other recommendations the Committee studied the available books recently published in the field of Civil Engineering. It was the aim of the committee to make a selection that would give a good distribution of subject matter, and place books in the library that would carry authority in their field.

Following is the list selected for purchase:

Pile Foundations, 2nd. Ed. Robert D. Chellis
Frame Analysis, Woodhead and Hall
Stresses in Shells, Wilhem Flugge
Soils and Soils Engineering, Reuben H. Karol
Electronic Surveying and Mapping, Simo Laurila
Manual on Industrial Water and Industrial Waste Water—STP, 2nd. Ed. Am. Society for Testing Materials
Theory of Elastic Stability, 2nd. Ed. Timoshenko & Gere
From Theory to Practice in Soil Mechanics, Selections from the writing of Karl Terzaghi.
Manual of Photographic Interpretation. Robert N. Colwell, American Society of Photogrammetry.
Professional Engineers' Examination Question and Answers, William S. LaLonde
Design of Steel Structures, Boris Bresler and T. Y. Lin
Design and Construction of Ports and Marine Structures, Alonzo DeF. Quinn
Air Pollution Control, Faith.

The following books were received as gifts:

Design of Water-Resource Systems, from Gordon M. Fair
Comparisons in Resource Management, from Arthur Maass

THOMAS C. COLEMAN, *Chairman*

## REPORT OF ADVERTISING COMMITTEE

Boston, Mass., March 22, 1962

*To the Boston Society of Civil Engineers:*

The activities of the advertising committee for this past year was limited to the consideration of positive measures to be taken to assure continued and possible increased revenue from advertising in the Society's Journal.

Accordingly the Committee recommends the following:

1. Prepare a list of prospective advertisers, such as manufacturers, distributors, special services, etc.
2. Initiate a program to attract more professional cards from all engineers in private practice whether or not they are members of BSCE.
3. A "Follow Up Program" should be planned so that each committee member would have specific assignments.
4. Records and progress reports should be prepared and maintained in the office for continuous reference and guidance for future committees, so that the transition from one committee to the next will be smooth and procedures simplified.

HARRY R. FELDMAN, *Chairman*

## REPORT OF THE HOSPITALITY COMMITTEE

Boston, Mass., March 8, 1962

*To the Boston Society of Civil Engineers:*

The Hospitality Committee submits the following report for the year 1961-1962.

A total of nine meetings of the Society were held during the past year. Included in this total were the Annual Dinner, a Student Night Meeting, and seven regular meetings of the Society.

Catered dinners were served prior to six of the nine meetings.

The average attendance of members and guests for all nine meetings or dinners (using the large attendance figure) was 70, as compared to last year's average of 73.

Attendance at regular meetings of the Society during the past year was 52 persons per meeting, which equaled last year's average. Attendance is, however, still below the levels recorded from 1957 to 1960. It is therefore recommended that a concerted effort be made during the forthcoming year to encourage more active participation of the membership in society functions.

SUMMARY OF MEETINGS AND ATTENDANCE

| Date | Place | Attendance Meeting | Attendance Dinner |
|---|---|---|---|
| March 16, 1961 | M.I.T. Faculty Club | 35 | 160 |
| April 12, 1961 | United Community Services Building | 65 | 50 |
| May 17, 1961 | United Community Services Building | 18 | — |
| September 27, 1961 | United Community Services Building | 70 | 55 |
| October 25, 1961 | Mass. Institute of Technology | 110 | 110 |
| November 15, 1961 | United Community Services Building | 24 | — |
| December 13, 1961 | United Community Services Building | 90 | 65 |
| January 24, 1962 | Society Rooms | 30 | — |
| February 21, 1962 | United Community Services Building | 65 | 46 |

CLEMENT D. ZAWODNIAK, *Chairman*

## REPORT OF THE MEMBERSHIP CENTRAL COMMITTEE

Boston, Mass., March 22, 1962

*To the Boston Society of Civil Engineers:*

I. Status of Membership as of March 22, 1962

| | |
|---|---|
| Total Membership | 1055 |
| New Members this year | 25 |
| New Junior Members | 7 |
| Transfers from Junior to Member | 14 |
| Reinstatements | 7 |
| Resignations | 7 |
| Deaths | 8 |

II. Activities of Committee

There was very little productive activity of the committee this year, however, we offer the following recommendations with the hope that in the following years there will at least be some area in which the Membership Central Committee can get started.

A. Investigation of check lists for prospective members.
  1. Mass. Board of Registration list
  2. A.S.C.E. List
  3. Blue Book Roster
  4. Firms employing Civil Engineers

B. Appeal to the present members for active participation in getting new men interested.
  1. At the first general membership mailing include the application, flyer, extracts from the Constitution and By-Laws and a short well worded request to the member to use the enclosures on a prospective colleague.
  2. Send the same data to prospective members outlined in A 1, 2 and 3.
  3. Send appropriate number of sets of data to item A 4.

C. Prepare a questionnaire to the membership.
  1. Requesting basic data pertaining to meetings and recommendations in general.
  2. Ask for specific answers to questions.
    a. Are we doing all we can for the membership
    b. What principle benefits do you desire
    c. Why do you or do you not attend your Section Meetings

D. Increase publicity at local levels.
    a. For members participating in Society activities
    b. Officers and Program Chairmen
    c. Speakers and Programs

E. Provide the necessary budgetary requirements to cover expense of the mailing and printing of the recommendations.

HARRY R. FELDMAN, *Chairman*

## REPORT OF THE JOHN R. FREEMAN FUND COMMITTEE

Boston, Mass., March 22, 1962

*To the Boston Society of Civil Engineers:*

The John R. Freeman Fund Committee during the past year paid for the cost of preparation and publication of the "Report of the Committee on Floods," a total of $2217.92.

The Committee is offering a Scholarship this year. The requirements are the same as that offered four years ago (1958), except the stipend has been raised to a total of 5,000 for a single and $6000 for a married man. Applications close on March 26, 1962. So far only one application has been received.

HOWARD M. TURNER, *Chairman*

## REPORT OF JOINT LEGISLATIVE COMMITTEE

Boston, Mass., March 8, 1962

*To the Boston Society of Civil Engineers:*

No legislative bill of major interest to engineers was taken up during the 1961 Session.

A check on bills filed for the 1962 Session shows the following items of interest.

| *Bill No.* | *Subject* | *Report* |
|---|---|---|
| H1310 | Petition of Peter J. Cloherty for legislation to authorize the incorporation of professional corporations to practice specified professions. | None as of 3/7/62 |
| H585 | Petition of Francis H. Carr, Jr., and Julius Ansel relative to the issuance by the Board of Registration of Professional Engineers and Land Surveyors of certificates of registration to certain public employees holding the grade of permanent "junior civil or other engineer" or higher. | Next Annual Session House 2/26/62 |
| H1563 | Petition of Allen E. Gifford that public officials be prohibited from requiring that bidders on public construction contracts procure insurance and surety bonds from any particular insurance or security company. | None as of 3/7/62 |
| H2367 | Petition of James R. McIntyre that the seals of registered professional engineers be required to bear an identification of the field or fields of practice of said engineers. | Next Annual Session House 2/26/62 |

The Committee opposed H585 and were instrumental in having the sponsor ask for leave to withdraw.

We also took an active part in the preparation of a list of suitable engineers for possible appointment by the Governor to policy making positions in various State departments. This list was sponsored by Massachusetts Section ASCE, MSPE and BSCE. Excellent co-operation has been shown by the Governor's office on this matter.

EDWARD WRIGHT, *Chairman*

## REPORT OF THE PUBLIC RELATIONS COMMITTEE

Boston, Mass., March 22, 1962

*To the Boston Society of Civil Engineers:*

No formal meetings were held during the year by the Public Relations Committee as no subject matter developed that warranted a meeting.

Copies of notices of meetings were sent to approximately fifty of the Engineering Officers for posting.

The undersigned called upon representatives of the Boston daily newspapers requesting their co-operation in publicizing the Society and Section Meetings. The resulting publicity was minimal, and it appears that the only way the Society can obtain adequate publicity is to engage the part-time services of a public relations man.

JOHN F. FLAHERTY, *Chairman*

## REPORT OF COMMITTEE ON SUBSOILS OF BOSTON

Boston, Mass., March 22, 1962

*To the Boston Society of Civil Engineers:*

Following is the Annual Report of the Committee on Subsoils of Boston:

In continuing the work of collecting boring data in Greater Boston the Committee has prepared a questionnaire to be sent to architects, engineers, and boring contractors requesting information on borings put down since the last publication data in 1949.

The Boston Redevelopment Authority has expressed interest in this program and hopes to be able to help with the cost. As the necessary money becomes available the data will be prepared for publication.

DONALD G. BALL, *Chairman*

## REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION

Boston, Mass., February 19, 1962

*To the Sanitary Section*
*Boston Society of Civil Engineers:*

Four meetings of the Sanitary Section were held during the past year. A brief account of each meeting follows:

March 1, 1961—Annual Meeting. The following officers and members of the Executive Committee were elected:—Chairman, Robert H. Culver, Vice-Chairman, George W. Hankinson, Clerk, Charles Y. Hitchcock, Jr., Executive Committee, Francis T. Bergin, James M. Symons, William C. Traquair.

Richard M. Power, Associate Sanitary Engineer, Division of Sanitary Engineers, Massachusetts Department of Public Health presented a paper entitled "Small Sewage Treatment Plants." The number of members and guests was not recorded, but the room was well filled. Attendance was 54 members and guests.

June 3, 1961. Annual Outing and Joint Meeting with the Main Society. The Annual Outing this year consisted of a visit to the Lawrence Experiment Station where the members and guests viewed the activities of the Experiment Station. Following the visit to the Experiment Station, an informal luncheon was held at the Yankee Doodle Restaurant in Lawrence. At the luncheon, Mr. Joseph A. McCarthy, Chief of the Lawrence Engineering Experiment Station reviewed the history of the Experiment Station and described the present operation of and services offered by the Experiment Station. Eighteen members and guests were present.

October 4, 1961. At this meeting a paper on the subject of "Composting of Municipal Refuse" was presented by Mr. John S. Wiley, Sanitary Engineer Director Biophysics Section, Communicable Disease Center of the U.S. Public Health Service in Savannah, Georgia. The meeting was preceded by dinner at the Smorgasbord Restaurant. Forty-six members and guests were present at the meeting.

December 6, 1961. "The Pittsfield—Dalton Pollution Control Program," was presented by Mr. Joseph C. Lawler, Partner, Camp, Dresser & McKee. A Nominating Committee consisting of Harold A. Thomas, Jr., George M. Reece and Clair N. Sawyer was elected. The meeting was preceded by a dinner at the Smorgasbord Restaurant. About 75 members and guests were present.

The Executive Committee held three meetings during the year, at which the programs for the year were planned. Mr. John S. Bethel, Jr. was recommended to the Board of Government for appointment to represent the Sanitary Section on a Committee assembled by the Massachusetts Department of Public Health to develop a policy for the operation and maintenance of subdivision sewage treatment plants. The Executive Committee carried through the final printing and publication of the Sanitary Seminar Lectures.

The total attendance for the four meetings was about 194, for an average attendance of about 50.

The papers prepared for three of these meetings have been or will be published in the Journal.

CHARLES Y. HITCHCOCK, JR., *Clerk*

## REPORT OF THE EXECUTIVE COMMITTEE OF THE STRUCTURAL SECTION

Boston, Mass., March 1962

*To the Structural Section*
*Boston Society of Civil Engineers*

There were seven meetings of the Structural Section which were held as follows:

April 12, 1961. Joint meeting with main Society and Construction Section. Mr. William Mueser of the firm of Moran, Proctor, Mueser and Rutledge, and Captain Perry Boothe, C.E.C., U.S.N., spoke on the "Design and Construction of Bremerton Base Drydock." Attendance was 65.

May 10, 1961. Mr. Fred U. Severud of Severud, and Dr. Hannskarl Bandel, Elstad, Krueger Associates of New York City spoke on the "Structural Design of the New Earth Sciences Building at M.I.T." There were 45 present.

October 11, 1961. Mr. James Carey, Senior Technologist, Shell Chemical Company, spoke on "Prospects for Epoxy Resins in Structural Engineering." Attendance 50.

November 8, 1961. Professor Jerre Jennings, Head of the Civil Engineering Department at the University of the Witwaterstrand, South Africa, spoke on "General Soils and Foundations Problems in South Africa." There were 50 present.

December 13, 1961. Joint dinner meeting with Main Society. The talk was on the Fox Point Barrier, Providence, R.I. The speakers were Mr. John Leslie, Mr. Herbert Whittemore, and Mr. Eugene Groden, all of the Corps of Engineers. Attendance 85.

January 10, 1962. Robert J. Hansen, Professor of Structural Engineering, Massachusetts Institute of Technology, spoke on the "Feasibility of Structural Hardening against Nuclear Weapons." Attendance 45.

February 21, 1962. Joint Dinner Meeting with Hydraulic Section and the Main Society. Professor Howard, M. Turner of Harvard spoke on "New England Floods and the Society's Flood Reports." Attendance 70.

March 14, 1962. Annual Meeting of Structural Section. The following officers for 1962-63 were elected: Chairman, Percival S. Rice, Vice Chairman Harl P. Aldrich, Clerk, Max D. Sorota, Executive Committee, Mark M. Kiley, Thomas C. Coleman, Donald T. Goldberg.

Speaker of the evening was Dr. John B. Scalzi, Industry Representative, construction-structural design, U.S. Steel Corp., spoke on "Unusual and Efficient Structures Made Possible by Welding." Attendance 55.

The total attendance for the year was 465; average 57.

P. S. Rice, *Clerk*

# REPORT OF THE EXECUTIVE COMMITTEE OF THE HYDRAULICS SECTION

Boston, Mass., March 1, 1962

*To the Hydraulics Section,*
*Boston Society of Civil Engineers:*

The following meetings were held during the past year:

May 3, 1961—Mr. Philip A. Drinker, Research Geologist, Agricultural Research Service, Hydrodynamics Laboratory, Massachusetts Institute of Technology, discussed "Boundary Shear Stress Distribution in Trapezoidal Channel Curves." Slides were shown and a hydraulic model at the laboratory was demonstrated. Attendance: 20.

November 1, 1961—The meeting was held in the Society Rooms. Mr. Lee M. G. Wolman, Hydraulic Engineer, Charles T. Main, Inc. was speaker. Mr. Wolman's subject was "Hydraulics and Hydrology of the Niagara Power Project." Slides were shown and an interesting question period followed. Attendance: 32.

February 21, 1962—A joint meeting with the Boston Society of Civil Engineers and the Structural section was held at the Community Services Building following a roast beef dinner.

Mr. Donald R. F. Harleman called the meeting of the Hydraulic Section to order. The reading of minutes of the previous meeting was dispensed with and the report of the nominating committee was read and accepted. The nominating committee, consisting of the three previous chairmen, was as follows:

James W. Daily
Lee Marc G. Wolman
John B. McAleer

The following slate of officers for 1962 was approved:

Lawrence C. Neale, Chairman
Richard F. Dutting, Vice-Chairman
Keistutis P. Devenis, Clerk
Peter S. Eagleson, Executive Committee
Allen Grieve, Executive Committee
Nicholas Lally, Executive Committee

The speaker was Howard M. Turner who discussed "New England Floods and the Society's Flood Reports." The meeting was followed by a very interesting discussion period. The meeting was adjourned at 8:45 P.M. Attendance: 66.

R. F. DUTTING, *Clerk*

## REPORT OF THE EXECUTIVE COMMITTEE OF THE SURVEYING AND MAPPING SECTION

Boston, Mass., February 14, 1962

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

Three meetings of the Surveying and Mapping Section were held during the past year as follows:

May 17, 1961—Joint Meeting with the Boston Society of Civil Engineers. Dr. David D. Jacobus, Senior Mechanical Engineer of Harvard University—Cambridge Electron Accelerator, spoke on "The Survey for the Cambridge Accelerator." Attendance 18.

October 18, 1961—Mr. U. M. Schiavone, Newton City Engineer, spoke on "Conversion of a Former Metropolitan Water Works Aqueduct to the Use of a Gravity Flow Sewer." Attendance 17.

January 17, 1962—Annual Meeting—The following officers were elected for the coming year:

| | |
|---|---|
| Chairman | Richard D. Raskind |
| Vice-Chairman | Rudolf S. Slayter |
| Clerk | Joseph E. Bodio |
| Executive Committee | Robert E. Cameron |
| Executive Committee | Alexander E. Manning |
| Executive Committee | John P. Hurney |

Following the elections, Mr. Philip H. Kitfield, Chief Engineer—Massachusetts Turnpike Authority, James A. Armstrong, Resident Engineer—Massachusetts Turnpike Authority, Edward J. Comeau, Field Engineer—New England Survey Service spoke on "The William F. Callahan, Jr. Tunnel." Attendance 50.

Total attendance for the year was 85; average attendance was 28.

Roy L. Wooldridge, *Chairman*

## REPORT OF THE EXECUTIVE COMMITTEE OF THE CONSTRUCTION SECTION

Boston, Mass., March 22, 1962

*To the Construction Section*
*Boston Society of Civil Engineers:*

The Construction Section continued to follow the long range program as discussed in the 1961 report by Frank J. Heger. The unofficial advisory group was reconvened to aid in furthering this program.

Three meeting dates were assigned this section and meetings were held on those dates as well as a joint meeting with the Main Society and the Structural Section. Those meetings, speakers, subjects and attendance were as follows:

March 22, 1961. John J. Schuren, Metcalf & Eddy spoken on "Artic Construction." Twenty-eight members and guests attended the meeting.

April 12, 1961. Joint Meeting with Main Society and Structural Section (refer to the Secretary's Minutes).

May 24, 1961. Mr. Joseph C. Yeager, Portland Cement Association spoke on "Concrete Floor Construction—Skilled Workmanship." Thirty members and guests attended the meeting.

January 3, 1962. Mr. Lloyd Cuticliffe, Instructor, M.I.T., spoke on "Applications of Operations Research in the Construction Field." Fifteen members and guests attended the meeting.

A program planned for March 22, 1962 is a talk by Mr. David Werblin of the Griffin Wellpoint Corporation on the latest methods of dewatering construction sites.

The section has under consideration, a series of meetings covering precast and/or prestressed concrete for building construction. It appears there is a great interest in this type of meeting.

The new officers of this Section are as follows: Chairman, James P. Archibald, Vice-Chairman Leonard Tucker, Clerk, Donald G. Goldberg, Executive Committee, Frank J. Heger, Harold Gillis, Robert A. Bierweiler.

ROBERT A. BIERWEILER, *Chairman*

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Volume 49 APRIL, 1962 Number 2

# BOSTON SOCIETY OF CIVIL ENGINEERS

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## PROFESSIONAL SERVICES



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Elliott F. Childs
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(Term expires March, 1963)

William L. Hyland
James W. Daily
Richard W. Albrecht
Roy L. Wooldridge
(Term expires March, 1964)

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Saul Namyet

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Ralph M. Soule

### STRUCTURAL SECTION AWARD

Myle J. Holley, Jr., *Chairman*

Saul Namyet
Richard Olney

### HYDRAULICS SECTION AWARD

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Clyde W. Hubbard
Lee M. G. Wolman

### SURVEYING AND MAPPING SECTION AWARD

Charles M. Anderson, *Chairman*

Lewellyn T. Schofield
Nelson W. Gay

### TRANSPORTATION SECTION AWARD

Alexander J. Bone, *Chairman*

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### CONSTRUCTION SECTION AWARD

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