SEVENTY-SIXTH LEGISLATURE

HOUSE NO. 310

House of Representatives, Feb. 18, 1913.

Tabled pending reference to a committee by Mr. Sanborn of So. Portland and ordered printed.

W. R. ROIX, Clerk.

STATE OF MAINE

IN THE YEAR OF OUR LORD ONE THOUSAND NINE HUNDRED AND THIRTEEN.

REPORT

OF THE

County Commissioners of Cumberland County

ON LOCATIONS, ETC., OF

PORTLAND BRIDGE

PURSUANT TO CHAPTER 209 OF THE RESOLVES OF 1911

Portland, Maine, February 15, 1913.

To the Seventy-sixth Legislature of the State of Maine:

Pursuant to the authorization of Chapter two hundred nine of the Resolves of nineteen hundred and eleven, approved March thirty-first, nineteen hundred and eleven,

We, the County Commissioners of Cumberland County have secured plans, estimates and locations of a bridge from a point on York Street in the city of Portland to the South Portland shore.

We have consulted with the city of Portland, the city of South Portland, the Boston and Maine Railroad, the Maine Central Railroad and the Portland Railroad Company in regard to the cost to be borne by the several interests and in obedience to the requirements of said Chapter, we herewith submit to you our report.

Having no authority to enter into any contract with any of the municipal or corporate interests represented it has been impossible to arrive at any definite agreements as to an apportionment of cost.

The engineering firm of Sawyer and Moulton of Portland has prepared plans and estimates and recommended locations for such a bridge as is in reasonable contemplation, and these plans, estimates and locations, together with their discussion of the same in their report to us are made a part of this report and are transmitted herewith.

Very respectfully submitted,

JAS. CARROLL MEAD,

JAMES H. McDONALD,

W. F. PILLSBURY,

County Commissioners of Cumberland County.

REPORT

ON

PROPOSED PORTLAND HIGHWAY BRIDGE.

February 12, 1913.

To the Honorable Board of County Commissioners,

Cumberland County, Maine.

Gentlemen:—

We have the honor to present herewith a report upon the construction of a highway bridge across Portland Harbor, connecting the cities of Portland and South Portland; the contemplated structure being designed to replace the so-called "Portland Bridge" and to provide in its stead a safer, more convenient and more adequate bridge for the accommodation of the existing and probable future traffic which may obtain during the life of such a construction as the exigencies of the situation appear to demand.

Respectfully submitted,

SAWYER & MOULTON,

By SETH A. MOULTON.

February 12th, 1913.

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REPORT

ON

PROPOSED PORTLAND HIGHWAY BRIDGE.

SAWYER & MOULTON, ENGINEERS, PORTLAND, MAINE.

FEBRUARY 12, 1913.

INTRODUCTION.

During the past generation the growth of urban communities has been so rapid that many American cities have been compelled to make vast expenditures for the reconstruction of inadequate water works; for the relocation and enlargement of highway systems that restricted traffic and precluded a healthy growth; and for the elimination of congestion from the waterways, harbors, docks and wharves, in order to afford adequate facilities for transportation, commerce and industry.

Drastic schemes involving the outlay of millions of dollars have recently been adopted and consummated in many cities for the purpose of ameliorating, if not entirely eliminating, all noisome, obnoxious and inefficient conditions that obtained, due to the grave errors committed in the past by those in civic authority. It is safe to assert that in nearly every instance where municipalities have been called upon to cope with formidable civic problems, such problems could have been almost entirely avoided by the adoption of a comprehensive predetermined plan of development based upon a careful analysis of existing conditions and probable future requirements, with the end in view to ultimately attain a maximum of economy and not for the sole purpose of securing a minimum initial cost. Profiting by the palpable mistakes of our forebears, we are constrained to approach the subject at hand with a full acceptance of the larger factors involved as paramount to the individual or corporate interests, with the single purpose of evolving a solution of the problem by the presentation of a project for the construction of a new bridge that will offer the greatest economical advancement of the commonwealth, realizing that such a procedure is bound to induce the acme of individual and corporate prosperity.

It requires only a superficial examination of the map of Portland to observe that the present business and commercial section of the city is restricted to the confines of a peninsular which, although most fortunately surrounded by water, is naturally isolated thereby from the adjacent mainland in all directions, with the exception of the narrow neck of land which connects the peninsular with the Deering district on the northwesterly end; and to appreciate that artificial connections must be provided to reach any other section of the mainland, if long detours around the margins of Back Bay and Fore River are to be avoided. With the topographical conditions which obtain along the Portland water front, it follows that the construction of artificial highways must necessarily obstruct to some degree either the movement of traffic upon the waterways or upon the roadways, and the extent to which such obstruction may be tolerated can only be determined by a careful study of the present and probable future volume of traffic upon land and water. The determination of these facts requires a study of the past, present and probable future development of the city and the contiguous country, with an analysis of the population growth and the probable area of its distribution; but as the growth of any section of a city depends upon its accessibility, the increase of population in any direction will be regulated and controlled by the adequacy of the thoroughfares and the transportation system. Hence, while under the existing conditions of development the zone of greatest population increase lies in the direction of Brighton Avenue and the Deering district, following the line of least resistance, this condition will undergo a radical change when a proper thoroughfare is opened leading to South Portland, because the foregoing sections will then have no special attractive feature to offer against the superior sites available for residential development in South Portland and Cape Elizabeth, now in disfavor only because of their inaccessibility due to the lack of adequate roadways and transportation facilities.

Coincident with the growth and distribution of population, it is necessary to take into account the possible and probable harbor development of that portion of the water front lying in a westerly direction from the new bridge, as this development will be the controlling factor which will determine the volume of water traffic that must pass through the draw or under the bridge.

It then appears that the selection of a proper design for the new bridge between the cities of Portland and South Portland involves the solution of all of the many problems encountered in the broad subject of city planning, comprising the population increase and distribution; the zone of territory tributary to the bridge, which will establish the importance of the structure as a highway thoroughfare and the transit facilities that it must afford; the probable industrial and commercial growth, with the contributory factors that may induce or augment the movement of vessels entering the inner harbor; and the method to be adopted for financing the construction of the bridge, as this most important feature will determine the period of life for which the new structure must be designed and the corresponding time period which must be covered in the investigations.

There seems to be every reason to accept as a fact that the portion of the cost for construction to be borne by Cumberland County, Portland and South Portland will be procured by means of a bond issue which will not reach maturity before the expiration of forty (40) years. This being the case, the bridge must be so designed that it will have an assured life of not less than forty (40) years, with a reasonable annual expenditure for upkeep; and care must be taken to adopt a structure of proper type and magnitude, in order that it may satisfactorily endure until the bonds are retired, unless an unjust debt is to be deliberately imposed upon the future citizen and tax payer, creating a condition which cannot be too severely criticised. On the above premises we have based all of the compilations and findings recorded in this report, assuming that the bridge must be in efficient service fifty (50) years from 1910, or in 1960.

In establishing the date of 1960, the physical condition of the existing structure was taken into account, as our investigations indicate that some method of reconstruction must be immediately adopted and there can be but a short lapse of time before a new structure must be provided.

Probably no local public project has incited the general interest which has been displayed in regard to the Portland Bridge; the question having undergone more or less active discussion for about five years. On this account there have been many opinions advanced as to the type, location, elevation, approaches and required width of the new bridge, also as to the manner in which the cost should be distributed between the several interested parties, Cumberland County, the City of Portland, the City of South Portland, the Portland Terminal Company and the Cumberland County Power & Light Company. The most important opinion advanced in these discussions is the necessity of providing a ramp or inclined approach leading from Commercial Street to the bridge, if a high level crossing of tracks and harbor is employed; the argument for the construction of the Commercial Street incline being based upon the theory that a large percentage of the vehicle traffic passing over the bridge emanates from the Maine Central freight houses and the territory on Commercial Street immediately adjacent thereto, and a casual survey of this district during the busiest hours of the day would seem to verify the accuracy of this claim; accordingly, it was deemed advisable to secure reliable information on this particular point, and the results of the investigations conducted are described herein in detail. Few, if any, of the other opinions advanced, with a possible single exception, are of sufficient importance to be specially mentioned in this report, particularly as the processes for deductions are described in full and these cover practically all suggestions that have been brought to our attention.

It is not within the problems of this document to advance suggestions or opinions in regard to the disbursement of cost among the five interested parties; but as the successful consummation of the project has been obstructed in the past by a prejudicial attitude in regard to this distribution, we feel as if it was incumbent upon us to remove this obstacle if possible. We refer to the single exception previously mentioned, which is an effort to impose the entire cost of the bridge upon the Portland Terminal Company, as it is claimed that this company has illegally occupied and obstructed the "County Crossing" with some of its trackage. Without endeavoring to establish the accuracy of this claim, but accepting it as correct, it seems as if an impartial consideration of the subject would lead to the amicable adjustment of the contention; either by granting the railroad a permanent right of way on the premises that it is now using and probably will continue to use, in turn securing from the Terminal Company certain concessions regarding the relocation of the "County Crossing" which will be of much more material aid toward the construction of a new bridge than the value of the illegally occupied land; or, if this course should fail, by taking such proper legal procedure as may be necessary to settle the dispute, instead of permitting a subject of such minor importance to block entirely an improvement that will be of incalculable value to the entire community.

We wish to express at this time our full appreciation of the liberal spirit and kindly assistance that has been extended to us by all of those parties whom we have approached for information and who have unstintedly given of their time and knowledge to furnish us with much of the information contained in this report, including the Honorable Clinton White of the Massachusetts Board of Railroad Commissioners; the Honorable B. Leighton Beal, Secretary of the Boston Transit Commission; Colonel Craighill, Corps of Engineers, U. S. Army; Mr. Bion Bradbury, Jr., Commissioner of Public Works; Mr. John Calvin Stevens; Mr. B. T. Wheeler, Chief Engineer of the Portland Terminal Company; Mr. David E. Moulton, Counsel for Portland Water District, and Mr. Raymond F. Bennett of the Bennett Contracting Corporation; also to acknowledge the support of our engineers and office assistants who have labored constantly day and night to complete the plans, estimate and text of this report at the earliest possible date.

POPULATION GROWTH.

Three methods have been applied for the purpose of ascertaining the probable population in Portland, South Portland and Cape Elizabeth in 1960.

First: By increasing the population each ten years from 1920 to 1960 by the same normal percentage of increase as has been shown for the growth of these communities by the available census figures, constituting a continuous record from 1850 until 1910; this normal increase having been an average of seventeen (17) per cent. for each decade.

Second: By computing the population from 1920 to 1960, accelerating the growth by assuming an influx of population which would average twenty thousand (20,000) for each decade ending 1920, 1930 and 1940, in addition to the seventeen (17) per cent. normal increase.

Third: By increasing the population of Portland from 1910 at the same average decade rate as obtained in twenty-three (23) American cities having about the same size as the City of Portland.

Sheet No. 1 illustrates graphically the summation of the results above outlined, the solid black verticals indicating the actual population growth from 1850 until 1910, as expressed on the vertical margins of the diagram. From 1920 to 1960 the black verticals are exactly seventeen (17) per cent. longer than the corresponding vertical for the prior decade, and on this basis, which will be undoubtedly the minimum growth, there will be not less than a total of one hundred and fifty thousand (150,-000) people within the boundaries of Portland, South Portland and Cape Elizabeth in 1960. We state confidently that this amount is the minimum, because the census records show, as noted on the accompanying Table I, that only five (5) per cent. of all of the cities in the United States with a population of not less than twenty-five thousand (25,000) have had a slower growth than the City of Portland, and that if Portland falls below this past normal average of seventeen (17) per cent. it must pass through a period of unprecedented lethargy, a condition which no right minded citizen will grant to be even a remote possibility.

The accelerated growth, illustrated graphically on Sheet No. 1 by the cross hatched projections above the solid black verticals for the decades from 1920 to 1960 inclusive, is derived by taking into account those factors which we know should have material effect upon the future growth of Portland. Without presuming to have in our possession information which cannot be procured by anyone having sufficient interest to make a thorough canvass of the situation, we feel that it will be conceded that our organization has a most intimate knowledge of the water power resources in this state, in addition to a knowledge of the general industrial and water power conditions throughout the eastern section of the United States. With this knowledge at our disposal, we make the following assertions advisedly:—

There are in the state of Maine numerous undeveloped water powers of sufficient magnitude and so situated that there can be economically delivered to the City of Portland three hundred thousand (300,000) horsepower for twelve (12) hours per day, three hundred and sixty-five (365) days in the year. In connection with this power the reader's first thought will revert to the probability that the power should be utilized at or near the point of development. This, however, is not the case, for the water powers under consideration are located in remote districts sufficiently removed from adequate transportation facilities and a supply of raw materials to preclude the possibility of their development were it not for the fact that the present perfection of electric transmission has made it possible to deliver the power to sites favorably located along the seacoast where both rail and water transportation facilities can be obtained. Ultimately the utilization of all of Maine's large water powers will be consummated upon the basis above outlined.

We feel that it is conservative to claim that not less than sixty thousand (60,000) of the above horsepower ought to be transmitted to the City of Portland for the industrial development of this port, and that failure to secure this amount of power will be due entirely to the attitude which the citizens assume toward industrial expansion.

The reason for selecting sixty thousand (60,000) horsepower as the minimum to be utilized in this vicinity is the fact that we know where such a volume of power can be secured and delivered to Portland at a cheaper cost per horsepower than can be found in any section of the United States, with the single exception of the district immediately adjacent to Niagara Falls, and this power can be delivered to Portland with an ample margin of profit to a power company for a unit price fifty (50) per cent. less than it would cost to produce the same power by steam from coal costing not more than three dollars ($3.00) per ton. Therefore, as previously stated, we can see no logical reason why there should not be delivered to Portland within the next twenty (20) years a total of not less than sixty thousand (60,000) horsepower, and in all probability this power will be utilized within the next ten (10) years. Certainly, if steps are not taken within this period to secure the power advantages available, they will be diverted to other points on the seacoast and Portland will be deprived of what it can now easily obtain.

The effect of power upon the prosperity and development of typical New England cities is given in Table II, and the contents of this table are in a large measure self-explanatory. In addition to the New England cities, the tabulation contains records for three cities in New York state, selected because they represent certain specific forms of industries, later described. It will be noted under Column 6 that for the five largest industrial centers in Maine the population averages two and forty-six hundredths (2.46) persons per horsepower utilized. This figure is obtained by dividing the total population in Column 5 by the total power utilized, as given in Column 2. It is interesting to note the effect of the varied industries upon the number of persons residing in each community per unit of horsepower.

Auburn is essentially a shoe manufacturing center, and it will be seen that the population per horsepower utilized compares favorably with Lynn, Massachusetts, which is a city of similar character, although Lynn has in addition the large machine works of the General Electric Company which tend to increase the skilled labor. Lewiston and Biddeford are essentially cotton centers, and it will be noted that the population per horsepower compares very favorably with that of Lawrence, New Bedford and Manchester, all cities having the same class of industries.

Particular attention should be given to the cities of Berlin, N. H., and Niagara Falls, N. Y., as both of these communities are built up entirely upon the utilization of large blocks of power for heavy manufacturing; Berlin being distinctly a paper city and Niagara Falls a center for paper, electrochemical and electrolytic products. Rochester, N. Y., is a city of varied industries and represents a class which we would expect to more closely parallel the future industrial development of Portland.

Under Column 5 the average population for all of the above cities is fifty-seven thousand seven hundred and twenty-eight (57,728) and the horsepower utilized thirty-six thousand eight hundred and eighty-seven (36,887), making the average population one and fifty-six hundredths (1.56) persons per horsepower. From results shown by the foregoing records, it is conservative to assume that the introduction of hydroelectric power will augment the population by not less than one (1) person for each horsepower utilized, and if sixty thousand (60,000) horsepower is delivered to Portland in equal blocks of twenty thousand (20,000) for each decade ending in 1920, 1930 and 1940 respectively, the population will be increased a similar amount, plus the seventeen (17) per cent. normal growth during this same period, and that the growth of Portland from 1940 to 1960 will continue to increase at not less than the past normal rate. The results of these deductions, as depicted on Sheet No. 1, indicate that in 1960 there will be a population in Portland of approximately two hundred and forty-six thousand (246,000).

Not satisfied with the conclusions arrived at on the basis of an accelerated growth, because these conclusions are subject to the criticism that we depend upon the realization of certain conditions to obtain such growth, we have compiled Table I which gives the population and per cent. of growth increase that has obtained in twenty-three (23) American cities generally corresponding in size to the City of Portland, the selection being made with the intention of eliminating any cities especially favored by some local conditions that caused them to become so-called "boom" towns, the average total increase from 1880 to 1900 being thirty-five (35) per cent. for each decade. On the same tabulation it is noted that all of the one hundred and sixty (160) American cities exceeding twenty-five thousand

(25,000) in population had a decade increase during the same period of thirty-nine and three-tenths (39.3) per cent. The vertical blockings to the right of the black and hatched verticals on Sheet No. 1 for the decades from 1920 to 1960 show what the population of Portland will be if the decade increase is thirty-five (35) per cent., or equal to the average of the twenty-three (23) cities given on Table I. This demonstrates that in 1960 we may look for a total population somewhat in excess of three hundred thousand (300,000).

A study of these figures reveals the striking fact that for some reason Portland has not enjoyed the prosperity which has been attained generally throughout the United States, and it is opportune at this time to seek the cause for this apparently restricted growth, if it can be ascertained. It is our opinion that in the past the slowness of Portland's growth can be attributed entirely to its remote location, combined with the fact that there are no special mineral or other natural resources in Maine and no vast territory tributary to Portland which would tend to accelerate the growth of a seaport town, particularly as Maine is a frontier state, with the barrier of the international boundary on the north and the Atlantic Ocean on the east, while at the south lies the port of Boston which is the transshipping point and purveyor for practically the entire New England district south and west of Maine. To overcome all of these obstacles which now exist and to incite a period of prosperity, Portland must necessarily utilize to the full extent the wonderful natural harbor now dormant, in connection with the abundant hydro-electric power at its disposal.

It may at first seem as if we were digressing from the object of this report in devoting so much time to the above subjects, but we propose to demonstrate that these subjects are all correlated and have most pertinent bearing upon the Portland Bridge project.

Taking what we consider a most conservative position, it has been assumed that the population of Portland will be not less than two hundred and fifty thousand (250,000) in 1960, and this total is the one which has been used in distributing the population over the combined territory comprising Portland, South Portland and Cape Elizabeth, in order to approximate the density of the population for the zone area which will be tributary to the bridge in 1960.

Table III contains the figures from which was compiled the diagram Sheet No. 1, and in addition it gives a segregated analysis for the growth of Portland, South Portland and Cape Elizabeth from 1850 to 1910. This table, in connection with the map Sheet No. 2, is the means whereby we have determined the population tributary to the Portland Bridge. From 1850 to 1890 the City of Portland was restricted to the peninsular protruding from the mainland between Back Bay and Fore River, with an area of about two and six-tenths (2.6) square miles; the Deering boundary line crossing approximately northeast from Thompson's Point in Fore River to Back Bay. For the decade ending in 1860 it will be noted that the population increase in Portland was nineteen (19) per cent., and for the decade ending in 1870 twenty-three (23) per cent., the density of the population being about twelve thousand (12,000) per square mile, an abnormal condition for a distinctly residential community, as the average density per square mile within the territorial limits of small American cities is approximately seven thousand (7,000), and the effect of this congestion was felt appreciably as will be noted by referring to the per cent. increase of population for the decades of 1880 and 1890 when there was an overflow from the city to the Deering districts which reduced the percentage of increase in the City of Portland proper to seven (7) per cent. for each decade.

In 1899 the annexation of Deering augmented the decade ending in 1900, occasioning an increase of thirty-seven (37) per cent., and during this decade the boundaries of the City of Portland were extended to comprise a total land area of about eighteen (18) square miles, of which practically seven (7) square miles were improved and thickly settled, making the density of the population in 1900 about seven thousand two hundred (7,200) per square mile, or a trifle greater than the average previously given for small American cities. The effect of this expension upon the general growth of the community within the confines of the new Portland area is revealed by the nineteen (19) per cent. increase for the decade ending in 1910.

We wish to call particular attention to the illuminating fact that by adopting a policy of expansion the prosperity of the combined cities of Portland and Deering was appreciably augmented, for in this respect history has simply repeated itself, demonstrating that desirable territorial expansion is a civic stimulant.

The distribution of the population in 1960 over the areas of Portland and South Portland will undoubtedly have a density of population of about seven thousand (7,000) per square mile, because it is natural to anticipate that the area within the present limits of the two cities will be occupied to this extent before any extensive overflow occurs to the surrounding towns. The land area of South Portland is approximately twelve (12) square miles, making the combined areas of the two cities thirty (30) square miles, or a territory sufficient to accommodate a total population of two hundred and ten thousand (210,000) with a density of seven thousand (7,000) per square mile, leaving a population balance of forty thousand (40,000) to be accommodated in Cape Elizabeth, which has an available land area readily susceptible to development of about twelve and one-half (12½) square miles, making the density of population about three thousand two hundred (3,200) per square mile.

In considering the figures above given it must be remembered that they are based entirely upon the present population within the confines of the areas under discussion, and that in addition to the development of these sections there will be a large suburban growth in the surrounding towns; but for the purposes of this report we have deemed it advisable to neglect this surplus population, because only a small percentage of it will be tributary to the new bridge, as will be noted by reference to Sheet No. 2.

The natural line of diversion for the flow of traffic towards the Vaughns Bridge city entrance and the Portland Bridge entrance will be near the present location of the Eastern Division of the Boston & Maine railroad, due to the natural topography, the presence of the railroad and the arrangement of the public thoroughfares. Therefore, we have considered that the populated area tributary to the bridge will be all of Cape Elizabeth and that section of South Portland east of an imaginary line which is designated on Sheet No. 2 as the "bridge zone line" extending northerly from the junction of the Cape Elizabeth and South Portland boundary to the present inner harbor shore line at Pleasantdale.

The territory tributary to the Portland Bridge in South Portland comprises an area of about four and two-tenths (4.2) square miles and will accommodate a total population in round figures of twenty-nine thousand (29,000), to which should be added the forty thousand (40,000) dispersed over Cape Elizabeth, making a total population tributary to the bridge of sixty-nine thousand (69,000) in 1960, as against a present population of about ten thousand (10,000).

PRESENT AND FUTURE BRIDGE TRAFFIC.

The present population in South Portland served by the existing traffic over the bridge and the direction of its bow from elements from which must be ascertained the volume of traffic which will exist in 1960, and the magnitude of this last figure must be the criterion to adopt in establishing the importance of the bridge as a highway thoroughfare and in selecting the width of a bridge to afford unrestricted intercommunication between the two cities, which will undoubtedly have become a unit at the date under consideration.

For convenience in presentation, we have subdivided the travel over the bridge into three classes: Pedestrians, vehicles and electric cars; and watchers were placed at several vantage points upon Commercial Street, at the entrance of the bridge proper and around the Maine Central freight houses, for the purpose of observing and recording the source, direction of flow and volume of all traffic which passed over the bridge, and in addition the volume upon Commercial Street near the freight houses. These observations were carried on continuously from December 17th to December 30th inclusive (Christmas Day excepted) in 1912, or during a period of the year when it would be expected that a maximum of heavy teaming would be imposed upon the bridge and a minimum of pleasure travel.

The diagram on Sheet No. 3 (*) graphically depicts the results of our investigations in reference to vehicle traffic, and a careful study of this diagram is very essential to a full com-

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(*) Tate Street, between Brackett and Tyng Streets, is not shown on this diagram. See Sheet No. 4 for correct street arrangement.

prehension of the situation. For the benefit of those unfamiliar with the situation it should be stated that the level of York Street between Brackett, Tate, Tyng, State and Park Streets varies from fifty-nine (59) feet to twenty-seven (27) feet above the level of Commercial Street, which is practically on an even grade at an elevation seventeen (17) feet above mean low tide; access to the bridge from the high level of York Street being afforded by an inclined wood trestle structure, designated as the Clark Street Bridge.

The natural direction of flow for practically all travel leading to the bridge from the central business portion of the city would be either over State or Park Street, thence up York Street to the Clark Street Bridge, if the character of the conveyance and the load carried was such that the grade on York Street from Park to Brackett Streets did not prevent the utilization of this course and make it advisable for the vehicle to continue on down the steep grade on Park Street from York to Commercial Streets, thence passing around the Maine Central freight houses onto the bridge.

Practically all of the travel from the wholesale district on Commercial Street naturally continues along this street when destined either for South Portland or the sections of the city in the direction of the Union Passenger Station; these two streams of traffic diverting at the junction of Commercial Street with the private way around the freight houses, the through traffic flowing northeast and southwest to and from the Union Station district, passing by the freight houses along Commercial

Street, while the major portion of the bridge traffic utilizes the right of way provided by the railroad (in lieu of the "County Crossing" on account of the numerous tracks passing over this public thoroughfare at grade), leaving Commercial Street at the projection of State Street, this traffic turning first southeast, then southwest, and again due south onto the bridge proper.

In addition to the large volume of through travel above described, there is a much greater vehicle traffic flowing to and from the freight houses on the northeasterly portion of Commercial Street, and these streams of travel, in addition to those flowing over the Clark Street Bridge, the "County Crossing" and from the freight houses to the bridge, are proportionately illustrated by the width of the black line on the previously mentioned diagram Sheet No. 3; the figures given thereon being the average number of vehicles that daily passed the several points during the time period previously stipulated.

For convenience of comparison the relative volume upon the several roads is given in terms of percentage, considering that the total number of vehicles passing over the bridge is one hundred (100) per cent. It will be noted that the section of Commercial Street east of the Maine Central railroad has two and one-third (2 1-3) times more traffic than the total which passes over the bridge; that of the entire volume on Commercial Street at this point two hundred and forty-seven (247) vehicles, or forty-five (45) per cent. of the total passing over the bridge and less than one-fifth (1-5) of that on the easterly section of Commercial Street, pass around the freight houses onto the bridge; that three hundred and eleven (311) vehicles, or fifty-seven (57) per cent., continue on in an easterly direction along Commercial Street, or a volume greater than that which is diverted onto the bridge; and that an average of only thirty (30) vehicles, or five and one-half (5½) per cent. of the East Commercial Street total passing to the bridge, utilize the "County Crossing;" and eighty-two (82) vehicles, which is only fifteen (15) per cent. of the bridge total or about one-fourth (1-4) of the volume passing by the freight houses on Commercial Street, emanate from the Maine Central Railroad freight houses, the balance of the travel upon the bridge, or thirty-four and one-half (34½) per cent., entering via the Clark Street Bridge.

These figures indicate that the demand for an inclined roadway leading from Commercial Street to a high level bridge is founded upon a fallacious theory, as such a structure would be provided solely for the purpose of accommodating only fifteen (15) per cent. of the vehicles using the bridge, while the construction of such a ramp would obstruct the volume of traffic passing along Commercial Street already almost four (4) times in excess of that which would utilize the incline, in addition to imposing restrictions upon the travel to and from the freight houses which has a volume of almost sixteen hundred (1,600) per cent. greater than that which would utilize the proposed inclined bridge approach. It might be possible by the wholesale condemnation of property on either the north or south side of Commercial Street to construct an incline such as has been suggested, but the expense of such a procedure would be abnormal when compared with the benefits to be derived. On the other hand, the diversion of the through traffic from Commercial Street to the new bridge at a position more remote from the freight houses would materially aid in eliminating the congested conditions now existing, and which will later become more aggravated, without imposing any material additional expense for transportation, if it appears advisable to construct a high level bridge in order to obtain greater freedom for traffic on both the roadway and upon the water; because it will be necessary to expend a given amount of energy to climb to the altitude of the new bridge from Commercial Street, whether or not a short, steep, artificial incline be provided or a long detour be made with easy grades. We, therefore. conclude that in the event of the selection of a high level bridge the necessity for constructing an incline from Commercial Street may be ignored, since vehicles are the only conveyances that might be benefited by this incline.

The present approach for the electric railway to the bridge is along York Street (as shown on the Key Plan Sheet No. 4), the cars turning down the abrupt ten and seven-tenths (10.7) per cent. grade on Park Street to Commercial Street, thence making three (3) sharp turns around the right of way provided east and south of the freight houses onto a trestle owned by the Cumberland County Power & Light Company which parallels the public bridge up to the swing draw, where an "S" turn is made onto the public draw-span, a similar "S" turn leading from the southerly end of the draw onto a pile trestle owned by the railroad, which extends to the South Portland shore, where another "S" turn is made to gain access to the public highway.

Considering the conditions which obtain in relation to the present arrangement of the trolley car tracks, it seems almost unnecessary to state that the car service between Portland and South Portland will be vastly improved by the construction of a high level bridge; for, instead of the series of eleven (11) turns now required to pass from York Street in Portland to Ocean Street in South Portland, only three (3) easy turns will be necessary in the same distance; and in addition the exceedingly bad grade will be eliminated between York and Commercial Streets on Park Street, with the ample opportunity which it affords for a serious accident if a brake chain should fail or if an air brake refused to operate.

From the accompanying car schedules, Tables VII and VIII, which were furnished through the courtesy of the Cumberland County Power & Light Company, it will be seen that electric cars now cross the bridge four hundred and twenty-six (426) times daily between 5:55 A. M. and 11:15 P. M., and that there is a car going in each direction upon the bridge on an average of every five (5) minutes throughout the above time. Owing to the fact that a double fare is collected from a large percentage of the passengers that patronize these cars, it was impossible for the Railroad Company to furnish an accurate record of the number of passengers crossing the bridge daily, because there was no means of determining the number of double fares collected. It will be observed, however, that for one hundred and thirty-seven (137) of the trips in each direction, or more than sixty-four (64) per cent. of the total, the cars have a seating capacity for forty (40) passengers, indicating that the patronage is sufficient to warrant the capacity which these larger cars afford. It is, therefore, safe to assume that the average number of passengers per car is not less than five (5), probably not less than ten (10), for each crossing, making the total daily number of passengers from two thousand (2,000) to four thousand (4,000), or an average of three thousand (3,000), to accommodate a population which does not exceed eight thousand (8,000). The records of the Boston Transit Commission indicate that the demand for transit facilities increases more rapidly than the population, but ignoring this fact and considering that the car passengers will increase in direct proportion to the population, the total number of passengers crossing the bridge in 1960 will be in excess of twenty-five thousand (25,000), meaning that the bridge must be continually occupied by cars; and to facilitate this car movement ample width of roadway must be provided.

The pedestrians crossing the bridge, as obtained at the time when the vehicle traffic was observed, averaged four hundred and thirty-six (436) per day. In addition to the above, there were seven hundred and twenty-eight (728) passengers in the several types of conveyances, other than electric cars, crossing the bridge. On the basis of an increase applied in the same manner as that adopted for the car patronage, a total of more than three thousand seven hundred (3,700) pedestrians and about six thousand three hundred (6,300) vehicle passengers, or a total of thirty-five thousand (35,000) people, will use the bridge daily in 1960, and this thoroughfare will have become an arterial highway of first magnitude. It is our opinion that the figures presented above are too conservative and that long before the imposed life of the new structure has expired it will be subject to a volume of traffic far in excess of that which is herein contemplated. Therefore, especial care must be taken to adopt a design of ample capacity to accommodate a traffic equal to that which we have assumed, and if practical the bridge must be built at an elevation which will preclude any unnecessary obstruction to the highway travel from the opening of the draw-span, and a type of draw-span must be selected which can be opened and closed with a minimum of lost time. This contention is to a large extent corroborated by a record of the volume of travel taken on Saturday and Sunday, Aug. 8th and 9th, 1908, when the total number of persons crossing the bridge was eight thousand seven hundred and seventy-eight (8,778) and twelve thousand nine hundred and eighty-five (12,985) respectively.

HARBOR DEVELOPMENT.

Portland is the only city of any importance in the United States either on the Atlantic or Pacific seacoast which has not commenced on the improvement of its harbor facilities or conceived a plan for the full utilization of this most valuable asset, although it is universally conceded that Portland harbor is the finest upon the Atlantic coast so far as natural advantages are concerned. We regret the necessity of transcribing such a statement, when practically every seaport city of the entire civilized world is endeavoring to improve its facilities for industrial development along the water front, with full realization that such use is of paramount importance to the prosperity of the community immediately adjacent thereto. While the development for commerce is a desirable feature, the exploitation of the water fronts for this purpose is a detriment to any city, as the available space which otherwise would be occupied by industrial establishments that permanently augment the population and wealth, is devoted to railroad and steamship lines for the purpose of transhipment, affording only a transitory benefit to the cities thus encumbered.

While the present dormant state of Portland harbor is a condition to be deplored, there is one saving feature which if immediately taken advantage of may be of sufficient importance to compensate in a measure for the past somnolence; this is the fact that a large percentage of the most attractive sections of the water front are not now occupied, owned or controlled by railroad or steamship interests and that these sites are available for the construction of docks and wharves that may be devoted to industrial uses. Combining this unexcelled opportunity with the advantages of the available hydroelectric power described under "Population Growth," Portland is destined to become one of the most prosperous and attractive cities in the United States, but to ultimately enjoy the benefits which are now readily within its grasp care must be taken not to introduce a harbor obstruction by the injudicious construction of a bridge which, while it may be entirely adequate to accommodate water and highway traffic under existing conditions, must in the event of a harbor development interfere with both; as the interjection of such an obstruction would certainly prevent a realization of the harbor possibilities west of the site of the new structure.

To meet the above contingencies, it is necessary to outline a reasonable project for future development and to determine what effect the consummation of such a project will have upon the design for the new bridge. This can be reasonably predetermined by comparing the present developed wharfage west of the bridge with that which may be completed during the life of the new structure.

Following the line of reasoning above outlined, we have prepared the accompanying Sheet No. 5, showing the present harbor and wharfage development, also what we consider would be a reasonable utilization of the unimproved water front on the north shore of South Portland east of the new bridge and for the Fore River inner harbor west of the bridge in both Portland and South Portland. The solid black wharves and piers shown on this map indicate the present development of the entire water front west of the breakwater light, and the shaded portions the contemplated development. We do not intend that this plan should be interpreted as representing what we consider to be the most effective utilization of the harbor, but it is a reasonable arrangement based upon the most approved modern practice for harbor improvements, comprising the dredging of channels and the depositing of the excavated material between quay walls, forming substantial piers which protrude from the mainland to the main channel between deep water docks where vessels may lay and discharge or receive their cargoes to and from warehouses, factories and industrial plants constructed either on the piers or adjacent to them.

It may be well to mention at this time that the scheme for harbor development presented on Sheet No. 5 was not evolved solely for the purpose of this report, but that it is the result of studies extending over a period of some three years during which the possibilities for the development of the entire water front of Portland have been under consideration, and that these studies have required a vast amount of research work which could not possibly have been accomplished within the time limit at our disposal for the compilation of this report. We wish to call particular attention to a feature which is considered of vital importance in modern harbor development; this is the fact that instead of restricting and narrowing the channel by advancing the bulkhead line and filling up the mud flats the reverse course should be pursued and the area of the waterways increased by excavating channels into the mud flats, thus securing a much more extensive dockage space than could otherwise be obtained, the principle being that it is ultimately cheaper to create artificial waterways than to make artificial land, and that the creation of the artificial waterways affords the material for the construction of imperishable wharves upon which substantial structures may be erected.

The modern steamship must be afforded every possible facility for quickly discharging and receiving its cargo and the harbor which affords a maximum of these facilities is the one to which the most desirable steamship business will be attracted, because, while a few hours', or even days', delay upon a voyage in the old days of sailing vessels was of minor importance, the modern steamship runs upon scheduue time and the failure to meet this schedule or the loss of a single trip during a season may be sufficient cause to prevent the steamer from yielding a profit to its owners. So, in addition to supplying all of the most improved mechanical devices for unloading and loading vessels, it is important that there should be no obstruction offered to prevent a vessel from docking at its berth immediately upon its arrival in the harbor.

The present improved dockage west of the Portland Bridge has a wharf frontage of about four thousand six hundred (4,600) lineal feet. With a layout as shown on Sheet No. 5 the total wharf frontage, including that at present developed, would amount to sixty-five thousand (65,000) lineal feet, or in round figures an addition of sixty thousand (60,000) lineal feet. Assuming that the total development as outlined will be completed in 1960, a most reasonable assumption if any improvements are inaugurated, we have estimated that this development will be made progressively, commencing in the near future and proceeding continuously up to the decade ending in

1960, allowing about twelve thousand (12,000) lineal feet of wharfage improvement for each decade, and this is the figure employed to determine what the volume of water traffic may be, increasing the present traffic by the direct ratio between the present developed wharfage and that which will be completed at the end of each decade.

The accompanying Table IV shows the traffic through the present drawbridge channel, as given in the draw tender's record books covering the period from January 1, 1906, to January 1, 1913. The clear head room beneath the existing drawbridge is sixteen (16) feet from mean low tide, thus it is necessary to open the bridge for practically all passing craft, with the exception of low motor boats and row boats. An examination of the Tabulation IV clearly shows that a large majority of the openings are made for the passage of scows, tugs and craft other than vessels with high masts. It will be observed that there is an apparent discrepancy in the total column, the total number of vessels, scows, motor boats and tugs not corresponding with the number of openings required. There are several causes for this condition. In some instances an incoming and outgoing vessel with masts will be passed through the draw at the same time, and this is the reason for the discrepancy in the "Total" column between the number of "Vessels" passed and the "Openings." Also, many vessels are escorted by more than one tug and at the same time incoming vessels with tugs and outgoing tugs may be passing the bridge. Comparing the totals for each year in the last and next to last columns in Table IV, it will be noted that throughout the entire period covered more than fifty (50) per cent. of the openings were made to permit the passage of tugs or low craft.

On the diagram for the drawbridge openings, Sheet No. 6, we have graphically illustrated the records contained in Tabulation IV and have projected the possible drawbridge openings for each decade up to 1960; the solid black verticals representing the openings which have been and will be required to pass the low level craft with a bridge at approximately the same grade level as the existing structure, the unshaded verticals above the solid black sections indicating the openings for vessels with masts under similar conditions; the height for the verticals from 1920 to 1960 being determined by increasing the average for the period covered in the actual records from 1906 to 1912 in direct proportion to the amount of wharfage now developed and that contemplated at the end of each succeeding decade.

Particular note should be taken of one feature which this diagram forcibly impresses; this is that the length of the solid black portions representing tugs, scows and low level vessels for the years 1906, 1907 and 1908 are several times greater than the corresponding black verticals for the period from 1909 to 1912. To those familiar with Portland events it will be remembered that the Vaughns Bridge was in process of construction and that the channel to Vaughns Bridge was being dredged between the years of 1906 and 1908, and it was this comparatively small inner harbor improvement that occasioned the greatly increased amount of traffic and the consequent openings of the Portland Bridge. This is enlightening information, as it demonstrates conclusively that if the inner harbor improvements for each decade should even approach the amount previously estimated as probable (that is, twelve thousand (12,000) lineal feet), the number of openings which must be made through a low level bridge will at least equal and probably greatly exceed those given upon the diagram.

From observations made as to the time consumed at each opening of the existing drawbridge, combined with information secured from other sources, it is safe to assert that roadway traffic must be interrupted for an average period of not less than five (5) minutes each time the drawbridge is opened.

Prior to 1912 there were several days when the openings exceeded twenty-five (25), indicating that the daily openings may be three and one-half (3½) times the number shown upon the diagram.

At the top of Sheet No. 6 is given a table comparing the daily interruption of traffic with high and low level bridges, compiled on the basis that the roadway will be closed for an average period of not less than five (5) minutes each time the draw is opened, although since this report has been in preparation the present draw has remained open many times for more than five (5) minutes. A scrutiny of the tabulation on Sheet No. 6 demonstrates the inadvisability of constructing a low level bridge across Portland harbor; for if it is erected and the inner harbor developed, either the roadway or the waterway traffic must be discontinued in 1960 for not less than eight (8) hours daily, a condition that could not be tolerated. Hence, as the bridge must of necessity be built prior to any extensive inner harbor work, it logically follows that the bridge must be designed in anticipation of such work, unless the harbor development is to be deliberately restricted.

EXISTING CONDITIONS.

A report was presented to a special bridge committee appointed by the Seventy-fifth Legislature which covered in detail the physical condition of the present bridge in 1911; the committee holding a public hearing on this subject in Portland during February of the same year. The result of the investigations conducted by Mr. J. R. Worcester, C. E., of Boston, the original designer of the draw-span; by Professor Harold H. Boardman, the Dean of the College of Civil Engineering, University of Maine; and our own firm were all presented at the public hearing, and the consensus of the expert opinions then advanced proved conclusively that the present draw-span was unsafe and inadequate. The summation of the result of the legislative inquiry, as contained in the sworn statements of the witnesses, was:—

First: The bridge was not originally designed to carry the heavy concentrated loads to which it was subjected; no provision having been made for the accommodation of electric cars or motor trucks.

Second: The condition of the steelwork in 1911 showed that a great deal of deterioration had occurred through corrosion.

Third: The deteriorated and over-stressed members of the draw superstructure must be immediately reinforced if an accident was to be avoided.

Fourth: The reinforcing of the bridge would only preclude the immediate danger of failure on account of its age and the large increase in the volume and weight of traffic, and to insure safety it would be necessary to limit the traffic, permitting only one electric car upon the bridge at any time.

Fifth: It appeared from the history of the construction of the draw-span foundation that its life depended upon the life of the steel shell with which it was surrounded, and as this shell was materially wasted by corrosion the yielding of it would certainly cause the failure of the pier; therefore, it would be necessary to keep vigilant watch of this foundation in order to prevent the accident which might occur.

Since the hearing in 1911, the Electric Railroad Company has issued orders that only one car at a time should be run over the draw-span, and other precautions were taken to prevent overloading.

For the purposes of this report we have investigated the present condition of the bridge and made new analyses of the stresses in the several members, ascertaining as near as possible the present supporting value of the deteriorated members for the purpose of determining the present carrying capacity of the structure. The result of these investigations and computations are recorded in Tables V and VI; Table V giving the conditions with restricted traffic and Table VI if the bridge is loaded to its full capacity.

The accompanying diagram Sheet No. 7 shows a skeleton elevation and plan of the present draw-span; the bracketed figures adjacent to the several members being the total pounds of stress which the designers used in proportioning the steel-work for carrying the loads to which they anticipated the bridge might be subjected, and the unbracketed figures are the stresses to which these members are actually subjected with the traffic over the bridge *restricted* to a *single electric car* and *one motor truck,* with *no other loading* of any description upon the bridge. The figures preceded by a plus sign represent compression stress and those by a minus sign tension stress as recorded in Columns 2 and 3 of the tables, and some of the members are alternately subjected to tension and compression when the position of the loads change upon the floor of the bridge. It will be observed that the end post Lo-U1 is strained by compression, with a restricted traffic, in excess of the stress which was contemplated by the designers of the structure; the same overstrained condition obtaining in the top chord U1-U2 and throughout the bottom chord from the end Lo to the panel point L4 of both the east and west trusses.

As failure will commence in a steel structure when the material is stressed beyond its elastic limit, no loading can be frequently applied which will stress the steel to this yield point.

The factor of safety of a member is the ratio of the maximum load applied to the permissible load to which it may be subjected without exceeding the yield point value. The factor of safety for an *entire* bridge is determined by its weakest member. Columns Nos. 4 and 5 in the tables show the yield point per square inch of the several main members of the trusses under both tension and compression, and Column No. 6, Table V, the actual stress per square inch to which these members are subjected with restricted traffic. Column No. 7 in the same table gives the factor of safety, determined by dividing Columns Nos. 4 or 5, depending upon whether the stress is tension or compression, by the unit stresses given in Column No. 6, when no allowance is made for the deteriorated condition of the steelwork.

Referring to Table VI, under Column No. 7 will be found what we estimate to be the present value of the steel in each member. Selecting in Column No. 7, Table VI, the value for the bottom chords L0-L2, L2-L4 and L4-L6, those portions of the structure most seriously deteriorated, it will be noted that they have only half of their original strength; therefore, the factors of safety in Table V, Column No. 7, for the same members should be reduced by one-half, indicating that the chords L0-L2 and L2-L4 are just sufficient to withstand without failure the stress to which they are subjected when only one electric car and a single motor truck are permitted upon the bridge at the same time. Again referring to Table VI, it will be observed that should the bridge be subjected to the possible loading which might be imposed upon it, if the traffic restriction as above specified was not enforced, the factors of safety for the bottom chords previously discussed are all below unity and the bridge would be bound to fail under these conditions.

The rate of deterioration in the steelwork from now on will be much more rapid than it has been in the past. Combining with this fact the possibility that no efforts towards traffic regulation could prevent the overloading of the draw in the event of a serious fire along the water front or other spectacle which might attract a crowd to this point, it must be granted that a persistent disregard of the weakness of the present structure may result in a serious disaster for which no excuse can be offered in view of the abundant evidence which has been presented on this subject.

The inadequacy of the draw-span for the proper accommodation of teams and other conveyances is best determined by an inspection of the accompanying Plate I, as this shows that it is impossible for teams or automobiles to pass each other when an electric car is upon the draw.

The condition of the timber work in the wooden portion of the highway structure leading from both shores to the draw-span is best described by examining the accompanying Plates II and III, showing the decayed ends of two of the main supporting girders.

The accompanying Key Plan, Sheet No. 4, shows the general layout of the streets, trackage, etc., over the entire territory appertaining to the approach of both the present and the proposed new bridges, and thorough comprehension of this plan is essential to an understanding of the present conditions and the improvements recommended in this report.

From now on it will be necessary to refer frequently to "elevations" in the description of locations, plans, etc., and to clearly interpret this report it must be remembered that all elevation figures are referred from mean low tide; that is, the elevation of mean low water is considered to be zero, and when the statement is made that a point or grade is at elevation fifty (50.) it means that this point is fifty (50) feet above the mean low water level in the harbor.

The Key Plan, Sheet No. 4, shows that Commercial Street opposite the section of York Street between State and Brackett Streets is at elevation seventeen (17.), or about fifty-nine and one-half (59½) feet below York Street at Brackett Street, fifty-two and one-half (52½) feet below York Street at Tyng Street, and forty-five and one-half (45½) feet below York Street at State Street, and that the distance from the northern boundary of Commercial Street to the southern boundary of York Street opposite Brackett Street is about two hundred and fifty (250) feet and opposite State Street about two hundred and thirty (230) feet; hence, the projection of Brackett Street from York Street to Commercial Street is a practical impossibility, as the grade would be not less than twenty-three (23) per cent. if it could be made uniform between these two points disregarding the necessity of providing head room over the railroad tracks; and the same argument applies to the projection of both Tyng and State Streets from York Street to Commercial Street. It then appears that although the city maps show these three (3) streets projected to Commercial Street, the locations can never be utilized practically. It should also be noted that Commercial Street has an elevation of approximately twenty (20) feet at the junction of Beach Street, making an even grade of about five (5) per cent. from Commercial Street to York Street opposite Brackett Street on Beach Street, while the elevation at the junction of Clark and York Streets is about forty-seven and five-tenths (47.5), making the grade upon Beach Street between Commercial Street and this point about six (6) per cent. At the junction of State and York Streets the grade is at elevation sixty-two and five-tenths (62.5), or thirteen (13) feet and six (6) inches below the level of York Street at Brackett, making the grade between these two points two and three-tenths (2.3) per cent., indicating that the highest elevation of York Street is between Brackett and Tate Streets, the peak being approximately at the junction of Brackett and York Streets, and this fact must be remembered when considering the recommendations later presented.

The "County Crossing" from Commercial Street to the present bridge is at practically elevation seventeen (17.) and the drawbridge floor at elevation twenty (20.), or only three (3) feet higher than the level of Commercial Street. To obviate the necessity of passing over the twenty (20) or more tracks now laid over the "County Crossing," the Railroad Company has provided on its property a right of way from Commercial Street, making a detour following the line of the Portland Railroad Company's tracks, thus eliminating all but one of the grade crossings, and either this approach or the approach from York Street over the Clark Street Bridge is now used for the greater portion of the vehicle traffic, as previously described in the discussion of diagram Sheet No. 3; the bulk of the traffic over the Clark Street Bridge consisting of pleasure vehicles, that around the freight houses being principally devoted to heavy teaming.

Commercial Street east of the railroad wharf bridge approach is now occupied by double electric railway tracks and by double steam railroad tracks, with spurs leading from the steam railroad tracks onto the several wharves. The railway traffic in connection with the vehicle traffic previously discussed makes this portion of Commercial Street a much congested section and any economical scheme which tends to relieve the present conditions will be worthy of serious consideration. None of the approaches to the present bridge can be called convenient, and the "County Crossing" is obviously dangerous. The ride on the electric cars from High Street to South Portland is most disagreeable, owing to the series of turns combined with the delays at the several highways and railway crossings. The entrance to the present bridge from the Clark Street Bridge, while not especially dangerous in itself if passed over with due caution, affords possibilities for a serious automobile accident in wet weather, on account of the sloping "S" turn illustrated in

Plates XIV and IV; Plate XIV showing this approach looking down, or east, onto the Portland Bridge, Plate XV from this entrance to the bridge looking up, or west. It takes but a small amount of study to discern that every existing feature in connection with the Portland approaches is objectionable, materially retarding the rapid movement of the bridge traffic and indicating that if a high level bridge can be provided at a reasonable expense with easy adequate approaches from both the wholesale and retail sections of the city, the transit facilities between Portland and South Portland will be greatly improved.

GENERAL SCHEME.

The selection of the recommended location and elevation for the new bridge was made by a process of elimination. The evidence previously presented under the sections covering "Present and Future Bridge Traffic," "Harbor Development" and "Existing Conditions" clearly demonstrates that a high level bridge should be adopted with a floor level located at a sufficient altitude above the harbor to afford clearance for the passage of the smoke stack of the highest tug, which must be a distance of not less than thirty-seven (37) feet above mean high tide, or forty-six and one-half (46½) feet above mean low tide. A head room clearance of twenty-two (22) feet should also be provided over the center of all of the tracks north and south of Commercial Sreet. As the top of the Boston & Maine rails north of Commercial Street are approximately at elevation eighteen and five-tenths (18.5), the elevation of the underside of the bridge at this point must be not less than forty and five-tenths (40.5). To satisfactorily meet both of the above conditions and provide ample depth for the framework beneath the roadway level of the bridge, the floor must be at elevation fifty-four (54.), and this is the grade determined upon as being that most desirable to adopt for the entire length of the bridge from the Portland end to a point across the draw that will permit a convenient grade for the approach in South Portland.

The next important question is to determine the best location for the new structure. It is obviously advisable to preserve the old bridge and utilize it if possible during the construction period, in order to eliminate the necessity of constructing a temporary bridge, which will involve an expenditure of not less than seventy-five thousand dollars ($75,000.00) that must be thrown away ultimately.

If the Portland approach was to be located at the most convenient point, it would start approximately at the foot of State Street; the bridge continuing this street in a straight line, terminating more nearly central with the developed section of South Portland than does the present structure, and this is the site which we would adopt if the ideal bridge was to be built, but such a structure would be materially longer than necessary at or near the present location. The total length of the bridge and the distance across the harbor will be practically the same east or west of the present structure; hence, the exact position to select near the old location will be determined by the construction difficulties encountered on the land ends, including the extent and value of the property which must be disturbed and condemned to provide proper approaches.

Locating the bridge east of the present structure will necessitate crossing over the Maine Central freight houses and yards, an expensive procedure if the work is to be prosecuted without seriously interfering with the present development; and, if carried in a straight line, the bridge will land on the South Portland end at a point where a new street must be provided in order to secure a proper approach. The combined difficulties presented from this course eliminate it from consideration.

A third and what still may prove to be the most satisfactory location is to start the bridge on the Portland end at some point between Clark and Brackett Streets, crossing diagonally over the existing bridge north of the present draw-span. This location will give ample opportunity for the location of the piers between the tracks leading to the freight houses without seriously disturbing the present arrangement; but a straight bridge laid out in this direction will land at practically the same point on the peninsular of Knightville as would a bridge located entirely east of the present structure. It may also be necessary to erect a section of temporary bridge and a temporary draw-span if the new bridge is thus located. We appreciate that the landing of the bridge on the easterly side of the Knightville peninsular necessitates the construction of a marginal roadway from the end of the peninsular up to Broadway in South Portland, but we feel that such a highway would prove of vast benefit to South Portland and that this scheme should not be abandoned without careful deliberation, on account of its many meritorious features, although it is probable that the cost of the bridge proper may be somewhat increased; and the location chosen for the purposes of this report is recommended with the reservation that the site above described should be studied seriously before taking definite action.

The location finally selected for the purpose of this report is immediately west of the old bridge, commencing at a point approximately opposite the junction of Brackett and York Streets and extending in a straight line from this point across the harbor, meeting the filled section of the old South Portland approach at an agle which will permit an easy entrance to Ocean Street without excessive condemnation of property, and allowing sufficient clearance between the old and new structures to preserve the former intact until the new bridge is ready for use. This location does not seriously interfere with any of the trackage leading to the freight houses, and the Clark Street Bridge can be maintained in service until it becomes necessary to complete the superstructure crossing it. Sheet No. 8 shows the tentative location of the new bridge, together with the general layout which we recommend for the construction of the approaches later described in detail.

Having determined upon the proper elevation and location, there remains only two important general features to be considered; these are, the width of roadway, and the width and depth of the channel which should be provided beneath the draw-span. We have devoted much study to the width problem and as a result the minimum roadway width which we would recommend is forty-six (46) feet between curbings, with a clear sidewalk space on each side of the roadway of not less than six (6) feet and six (6) inches, or a total space for each sidewalk from the street curbing to the extreme clearance line of the bridge of eight (8) feet, making the total width sixty-two (62) feet for those portions of the structure in which neither the roadway nor the sidewalk is obstructed by protruding trusses or beams, and a total width of sixty-four (64) feet where the supporting trusses project above the floor level. Initial economy dictates that the width of the bridge must be kept as narrow as possible. On the other hand, the bridge is primarily constructed for the accommodation of six streams of traffic, three flowing in each direction at different rates of speed, and provision must be made at the time the bridge is constructed to accommodate the growing volume of these streams with the increased velocity that they will certainly assume in 1960.

Unlike residential or business streets, this thoroughfare will not be obstructed by vehicles drawn up to the doorways of houses and stores, and the only element retarding a continuous flow will be the pace set by the slowest going conveyance, which may obstruct the entire volume of traffic following in the same direction unless sufficient width is allowed to permit the passage of vehicles without trespassing upon the right of way of those traveling of the opposite direction. The same reasoning applies to the provisions which must be made for sidewalks, and in this connection it must be remembered that although the present bridge is not extensively used by pedestrians, a new high level bridge will be a vantage point which will attract sight-seers and others, so that before the volume of traffic has reached the amount predicted in this report, the sidewalks will be extensively used.

Sheet No. 13 shows the comparative cross sections of numerous bridges, and an examination of it will show that our recommendations are conservative when compared with the widths which have been established for structures of much less importance than the one under consideration, as it will be seen that we have adopted a mean between the narrowest sidewalks and roadways which have been built, although the new bridge is a much longer structure than many of those illustrated, and in addition it serves now and will continue to serve a population greater than the Vaughns Bridge in Portland, the Connecticut River Bridge in Hartford, the Grand River Bridge in Grand Rapids, Michigan, or the Wabash River Bridge in Terre Haute, Indiana.

We contemplate that the new bridge will have two electric car tracks centrally located, as this arrangement is much more satisfactory and affords much better facilities for rapid transit than can be obtained when the car tracks are located on one side. This is due to the fact that when the car tracks are located central there is a natural division between the line of traffic flowing in either direction, and there is opportunity for vehicles to pass by turning onto the car tracks without danger of incurring a head-on collision. This natural separation of the lines of traffic is not provided when the car tracks are situated on one side of the roadway, and as the conveyances on a single roadway are moving in opposite directions it is necessary to provide a greater width for the two streams of travel than would otherwise be required; but this increased width does not eliminate the danger of a head-on collision, because there is nothing to prevent an awkward or careless driver from trespassing upon the right of way of vehicles traveling in the opposite direction.

The total clear opening for vessels between the rest piers of the present draw-span, deducting the space occupied by the central pivot pier, is one hundred and fifty (150) feet, and the channel was dredged originally to a depth of thirty (30) feet below mean low tide, but owing to the high velocity, due to the ebb and flow of the tide, this channel has been scoured to a depth of from thirty-three (33) to thirty-five (35) feet. While the United States Government will undoubtedly consent to the construction of a bridge which afforded a channel of the above area, such consent will not mean that they considered the channel adequate for the life of the bridge or that the Government waived its right to compel the removal of any construction in the event that communication with the inner harbor was restricted on account of the improper width or depth of this channel. It at first may seem unfair that the Government should assume such an apparently inconsistent attitude without offering some suggestions as to what it would approve. However, on consideration it will be conceded that the Government can lay no claim to occult powers, and, therefore, that it cannot prophesy what may arise in the future or sanction the permanency of any development which might sometime prove a serious detriment to the general interest of the people. It then devolves upon the designers of the bridge to predetermine as accurately as possible what the ultimate maximum depth of the channel may be and construct the foundations accordingly, also to establish a clear width of waterway more than ample to satisfy the present needs to preclude the possibility of its condemnation by the Government.

Fortunately, the Government has indicated in a most emphatic manner what it considers will be the maximum depth of channel required to accommodate the largest seagoing steamers in the depth which it has established for the locks in the Panama Canal; therefore, if we provide for a channel forty (40) feet deep, we are certain to have adopted as far-sighted a policy as the Government itself when it sanctioned the construction of these most important adjuncts to the Canal. No precedent of similar character is available for determining the free width of the channel, but judging from waterways of similar importance situated in harbors having a high state of development, it would appear that an unobstructed width of one hundred and seventy-five (175) feet between fenders will be adequate. This we feel to be especially true of the general elevation and type of structure which we recommend is adopted, because in addition to the clear waterway provided beneath the draw-span the design of the main harbor spans is such that tugs and other vessels without high masts may pass beneath the harbor spans which have the same clear head room as will exist under the draw-span proper.

DESIGN.

Having determined upon the general elevation, the most economical location, the width of the bridge roadway and the cross section of the channel required, the general type of structure remains to be considered.

For convenience in presentation, we have subdivided the design into five divisions as follows:—

First: Portland Approach.

Second: Commercial Street Viaduct.

Third: Draw-span.

Fourth: Harbor Spans.

Fifth: South Portland Approach.

Detailed descriptions of each section are hereinafter given in the order named, but before proceeding with these descriptions we propose to briefly discuss the properties of the engineering materials that are available, in order that our reasons for adopting the several types of construction may be fully understood.

The imposed life of the bridge necessitates the use of those materials which will have the greatest permanency, and the selection of the type of construction for each of the five divisions must be made with the intent of employing the most durable materials economically applicable.

Earth is the most imperishable of all engineering materials; hence, sound economy dictates that it should be used whenever practicable.

Masonry of concrete or stone ranks second in durability to earthwork; hence, when the exigencies are such that earthwork cannot be satisfactorily and economically employed masonry should be utilized.

Steel having correct physical properties, properly fabricated and well maintained, ranks third and should only be used where earthwork and masonry are inapplicable.

Wood exposed to the atmosphere is the least durable of all materials and should only be used in permanent structures when absolutely necessary.

The life of wood exposed to the atmosphere, or alternately exposed to water and air, may be prolonged for at least twice its normal life under such conditions if it be carefully treated with one of the several preservatives that are prepared for this special purpose.

Wood remaining submerged in water is imperishable and may be used indiscriminately under this condition when it is structurally sufficient.

Earthwork is practically indestructible and only has a very small amount of surface deterioration due to frost action.

Concrete masonry properly constructed will very slowly depreciate under the attack of the elements, although this material when subjected to the action of frost and salt water is severely taxed and may decompose rapidly; while granite masonry appears to resist the action of alternate thawing and freezing, to tidal conditions.

which our northern structures are subjected when exposed to

Unprotected structural steel succumbs very rapidly to the attacks of a salt water atmosphere, a fact clearly demonstrated by the physical condition of the present drawbridge which was constructed in 1895, only eighteen years ago, and yet today is depreciated to such an extent that some of its members have lost about one-half of their original strength. Structural steel subjected to the mechanical and chemical action of locomotive smoke will be rapidly eaten away, unless given constant attention, and although continual painting will effectively protect those portions of a steel structure that may be subjected to locomotive gases, paint is ineffective as a protective coating for the steelwork of bridge floors that are subjected to the impact of the mass of hot cinders and fine particles of coal which is impinged against it at a high velocity by the exhaust steam and hot air from the locomotive exhaust, unless the height of the structure above the locomotive stack is sufficient to permit the dissipation of the energy of these particles in the space which intervenes. We have records in our files of bridges subjected to both salt atmosphere and locomotive gases, as above described, which have endured only five or six years, it having become necessary to entirely replace the portions of the structures thus exposed within the above time limit.

Only meager information is available in regard to the character and bearing value of the geological formation upon which the new bridge must be founded, although there seems to be sufficient evidence to conclusively prove that no ledge will be encountered, except possibly under a short section at the northerly end of that portion of the bridge designated as the Portland approach. Recent borings and dredging near the contemplated site indicate that there is a strata of hard sand, beneath an overburden of mud and silt, that has ample sustaining capacity to afford adequate support for the bridge if built upon piling, and we have proceeded with our design accepting this theory.

The importance of accurately ascertaining the character of the foundation by means of borings cannot be too emphatically presented. This is a subject with which engineers and contractors are thoroughly familiar, as they know from experience that thousands of dollars might have been saved in the cost of work where hydraulic problems were encountered if comparatively small amounts had been expended for the purpose of predetermining the conditions which would have to be faced before the structure could be successfully completed. When an engineer possesses complete advance data for the preparation of a design, practically all of the perplexing and expensive problems that will be encountered can be anticipated, and the plans can be modified to avoid serious troubles; also the purchaser will be accurately informed in regard to the cost of the work.

The new bridge will be the most conspicuous object in Portland harbor. The very nature and magnitude of the structure make it a lasting monument of civic development, and as such it must be designed with a full acknowledgment of the fact that it should be architecturally adapted to the surroundings, otherwise it is bound to be a permanent disfigurement and a stigma, not only upon those who participated in its conception but also upon the community that tolerated its construction; for to quote from no less reliable authority than Henry Grattan Tyrrell, C. E., "the bridges and structures erected by a people or nation reveal their degree of esthetic taste and are a measure of their culture and civilization," and this statement comprehensively expresses the attitude held by such competent authorities as the late Mr. Carrere of the firm of Carrere & Hastings, the designers of Portland's City Hall; Professor William H. Burr, a famous bridge engineer and the designer of the contemplated Hudson Memorial Bridge to be erected in New York City; Mr. Gustav Lindenthal, formerly chief engineer of the Department of Bridges in New York City; and many others that might be mentioned if space permitted.

American engineers have attained an unenviable notoriety among their engineering compeers in Europe because they have shown such an utter disregard for the appearance of the bridges which they have created, maintaining the attitude that purely utilitarian structures can not be made attractive without sacrificing economy or by applying superficial ornamentation. This condition has primarily existed because practically all of the competent bridge engineers were formerly trained and retained in the employ of bridge companies whose sole object was to secure the largest price possible for the cheapest structure that could be devised. The keen competition of this system has resulted in the construction of many steel bridges that were inadequate and unsuited to the requirements. The famous Quebec bridge disaster was due primarily to the lack of competent, disinterested engineering talent, dependence being placed upon the engineering organization of the Construction Company, and the results show the inadequacy and undesirability of the competitive system.

Many of the bridges recently designed by American engineers independent of the thrall of the construction companies have proved that the attractiveness of a bridge does not depend upon superficial ornamentation, but upon the general outlines which are selected; hence, the arch type of structure has received much more attention than formerly, it having been found that with judicious design the arch form frequently proves more economical than the ordinary unsightly truss type.

The accompanying Plates IV to VII inclusive illustrate a few of the important arch bridges which have been built in this country, and Plates VIII to X inclusive some of the most famous European structures in both masonry and steel in which the arches have been most successfully applied.

Conceding the advantages of the arch type, we have utilized this form as the principal supporting members for the design presented with this report.

PORTLAND APPROACH.

No single problem in the design of the entire bridge originally appeared so formidable or seemed to offer less opportunity for the satisfactory solution than that of providing an easy, accessible and adequate approach for the Portland end of the bridge, although the final solution, as presented, is comparatively simple.

It must be remembered that we have already predetermined that the bridge will be at elevation fifty-four (54.), or fifty-four (54) feet above mean low tide, to provide proper head room over the harbor and over the railroad tracks adjacent to Commercial Street; also that the location of the bridge on the most economical line, all factors considered, places the Portland entrance to the bridge at a point slightly west of Brackett Street, but at this point the elevation of York Street is seventy-six (76.) or twenty-two (22) feet higher than the most convenient roadway level for the new structure.

To elevate the Commercial Street Viaduct so that the present grade of York Street could be utilized would necessitate the construction of an incline in the viaduct, and all traffic to the bridge from Commercial Street would be compelled to climb this additional twenty-two (22) feet simply for the privilege of going down again. The great volume of traffic from the business section of the city naturally enters York Street at State Street, at elevation sixty-two and five-tenths (62.5), or a point eight and one-half (8½) feet above the level of the new bridge, and if the Commercial Street Viaduct is raised to meet the elevation of York Street opposite Brackett Street, all vehicles from the business section of the city would be compelled to climb an additional fourteen (14) feet for the privilege of going down again.

It then appears that the "peak" in York Street, described under the heading of "Existing Conditions," should be avoided, if practicable, and this we feel has been accomplished by the arrangement shown on Sheet No. 12, which comprises briefly the condemnation of the present unattractive property on the south side of York Street between State and Brackett Streets, making York a two level street by constructing a retaining wall commencing about fifty (50) feet west of State Street, with a height of practically zero at this point, extending west about one thousand one hundred (1,100) feet to zero height at Clark Street, with a maximum height of twenty-two (22) feet in the section between Tate and Brackett Streets. This retaining wall will make York Street sixty (60) feet wide, the grade remaining as at present, and will permit the construction of what may be termed a new street or an addition to the width of York Street from the present foot of State Street to the entrance of the new bridge. The new street will have a clear width of not less than eighty (80) feet to accommodate two electric car tracks situated central in a roadway seventy (70) feet wide, with a ten (10) feet wide sidewalk on the southerly side; the filling for the new street to be confined by a retaining wall constructed along the edge of the high embankment north of the Boston & Maine railroad tracks. To provide an easy turn for vehicles traveling east and entering the new street from York Street, a clear width of thirty (30) feet has been allowed from the edge of the York Street retaining wall to the north curb of the new street, the intervening space to be made a grass plot or treated with shrubbery as desired.

The reconstruction above described provided a convenient entrance to the bridge for all traffic approaching it from the entire eastern section of the city whether or not it may emanate from the northerly business section or from the wholesale district on Commercial Street, the latter traffic reaching the new street by turning from Commercial Street up Maple Street and thence following York Street west to the bridge, or if desired the lighter conveyances may pass from Commercial Street to York Street up Park Street, thence proceeding to the bridge.

Referring to the Key Plan, Sheet No. 4, it will be seen that the bridge may be reached by the route above suggested over comparatively easy grades, the maximum being five (5) or six (6) per cent. for the short two hundred and fifty (250) feet haul up Maple Street; the maximum grade between High and Park Streets being two and one-half (2½) per cent., from Park to State Streets four and one-half (4½) per cent. There is an excellent opportunity to improve the easterly approach from Commercial Street by constructing a diagonal highway from Commercial Street to York Street, leading from the present foot of Maple Street to the intersection of York and High Streets, as shown by the dotted lines on Sheet No. 4; but we do not recommend the construction of this new way at this time, because we do not consider that the existing conditions are sufficiently objectionable to warrant the cost.

To provide an adequate approach to the bridge from the western section of the city, we recommend the improvement of Beach Street and the reconstruction of York Street from Clark Street to its junction with the "New" street previously described, making the average grade from Commercial Street to the entrance of the new bridge four and eight-tenths (4.8) per cent., with a maximum grade for a short distance on Beach Street of six (6) per cent., a condition necessitated by the presence of the archway over the Boston & Maine railroad tracks which it seems advisable to leave undisturbed, as it is a substantial structure and now affords only a minimum of clear head room over the tracks. To make the above improvements it will be advisable to condemn the small triangular section of property abutting on Clark, Summer, Brackett and York Streets, devoting the portion not required for the new streets to park purposes, with a general layout as suggested on Sheet No. 12.

We have estimated upon paving the steepest Beach Street grade with "Hassam" blocks, and the remainder of the reconstructed and new streets with a six (6) inch thick concrete slab.

A recapitulation of the benefits to be derived by constructing the approaches in the manner described reveals:—

First: The maximum haul to the entrance of the bridge from Commercial Street between Beach and Maple Streets will not exceed two thousand five hundred (2,500) feet.

Second: The bridge may be approached by conveyances from any direction without encountering objectionable grades.

Third: The carrying out of the recommended improvements will eliminate from the section under discussion obstructive buildings that would be always detrimental and objectionable features when situated in such close proximity to the entrance of an arterial highway.

Fourth: The recommended improvements would have a dignity commensurate with the importance of the structure to which they are an adjunct.

Fifth: Last, but by no means least, the obliteration of the existing conditions and the consummation of the improvements as laid out would so enhance the value of the property upon Clark, Summer, York, Brackett, Tate, Tyng and State Streets that the assessed value will be increased to such an extent in not more than twenty (20) years that the returns to the city from this source alone will more than pay the interest, maintenance charges and, in addition, a profit upon the sum invested to accomplish the desired result; if we include in the cost of this approach all of the property damage that may be incurred by the construction of the Commercial Street viaduct.

COMMERCIAL STREET VIADUCT.

Under the heading of "Design" attention was called to the undesirability of structural steel as a material when it is subjected to locomotive gases and to a sea laden atmosphere, the combination of these two being especially destructive. It logically follows, therefore, that the Commercial Street viaduct, crossing as it does a multitude of tracks, should be constructed of some other material. Therefore, we have adopted reinforced concrete, or steel encased in concrete, for the entire viaduct construction, comprising the section of the bridge from the Portland abutment to the draw-span pier No. 10.

To economically construct reinforced concrete, it is essential that the design should be symmetrical, otherwise the form work becomes exceedingly expensive, the cost for form work decreasing rapidly with the number of structural repetitions. To meet this condition and locate the piers where a minimum of interference will occur between them and the existing track and street layout, we have selected a span of one hundred (100) feet, center to center of piers, contemplating the construction of ten (10) of such spans, or for a total length of one thousand (1,000) feet. It will be observed by referring to Sheet No. 8 that the piers Nos. 1 to 7 inclusive are so situated that they do not obstruct the present trackage or require any extensive changes, although it will be necessary to slightly alter the location of a few of the Portland Terminal Company's tracks between piers Nos. 3, 4, 5, 6 and 7.

All of the foundations for the Commercial Street viaduct, with the exception of pier No. 9 which will be constructed in accordance with the specifications outlined in the following section describing the draw-span, will consist of a cluster of piles driven to the proper depth, sawed off at an elevation approximately at the level of mean tide, or possibly mean low tide, and capped with concrete, forming a platform upon which the concrete arch piers will be erected.

No difficulties will be experienced in constructing the foundations, but the erection of the concrete superstructure is a more formidable proposition, if it is to be accomplished without interfering with the occupancy of the tracks. To overcome this obstacle the viaduct has been designed as a series of ten (10) arcades, each arcade to consist of four (4) separated reinforced concrete steel ribs, the reinforcing to be fabricated structural steel arches of sufficient strength to support their own dead weight, also the forms and the concrete arch filling, without the aid of falsework which would have to be supported upon shoring from the ground; the steel arches being so designed that each rib can be set into position in its entirety after being fabricated at a convenient point upon the ground. When the steel arch ribs are in place the remainder of the viaduct superstructure can be completed without interrupting or interfering with the railroad and highway traffic beneath it.

The construction of the arcades in independent arch ribs affords several advantageous features. As previously stated under "Design," it is almost a certainty that the bridge will be founded upon a yielding material and that slight settlement must be anticipated while the load is being applied to the piers. To avoid the existence of indeterminate stresses, damage to the superstructure and the presence of unsightly cracks in the concrete arches or other portions of the concrete, each arch rib has been designed to rest in concave cast iron sockets securely embedded and anchored to the tops of the piers, in which will be seated convex bearing plates attached to the end of each steel arch frame, affording an articulated structure free to undergo any slight settlement which will occur in the foundations without injury; the arches having under all conditions a uniform bearing in the direct line of the thrust imposed upon them.

By depositing the arch concrete after the steel ribs have been subjected to the dead weight and falsework loadings, initial stresses will be induced in the steelwork, making it possible to apply a higher unit stress to the steel than could be allowed if the concrete and steel were placed simultaneously, owing to the difference in the elastic limits of steel and concrete. Hence, there will be a more economical utilization of materials.

We have estimated upon paving the roadway of the Commercial Street viaduct with wood paving blocks resting upon a sand cushion. The balustrade and lamp pedestals are designed to be constructed of artificial stone or concrete, with simple details, depending upon texture, color and mass for architectural effect; the design for this balustrade corresponding to that which will be employed upon the York Street and "New" street retaining walls, as shown on Sheet No. 12. Through the center of the balustrade railing conduits will be laid to receive the wiring for the lighting system.

The upper view on Sheet No. 10 shows the starting of the viaduct construction with a cross section through York Street at the point opposite Brackett Street and through the new street at the entrance of the bridge. On the accompanying West Elevation, Sheet No. 9, is shown the general appearance of the viaduct and the complete bridge.

It is our opinion that the design for the Commercial Street viaduct satisfies all conditions; for, it requires a minimum change in the present conditions; a permanent structure which will not be injured by locomotive gases or the presence of a sea laden atmosphere is secured, and it will require a minimum of upkeep and expenditure; no injury can occur from foundation settlement; and while not elaborated by any superficial ornamentation, its general outline satisfies all esthetic requirements.

DRAW-SPAN.

We now have to consider the most important portion of the structure, controlling as it does the interruption that must be imposed to some extent upon both land and water transportation by the presence of the bridge.

Two general types of design are commonly employed for movable bridges; the swinging and the lift. The rspective merits and demerits of each are as follows:—

A swing span is generally cheaper in first cost than the lifting or bascule type, otherwise it has no specially meritorious features. It offers a much greater obstruction in the waterway than the bascule bridge; it operates more slowly, because for the passage of any vessel it is necessary to open the draw to its full extent; it presents an unattractive appearance and no attempt at embellishment can make it otherwise; and last, but most important, a swing draw is exceedingly dangerous, because dependence must be placed upon gates and signals to prevent the roadway traffic from plunging into the water when the draw is open, and the failure of a signal lamp or the inadequacy of a gate, combined with the impracticability of constructing gates of sufficient strength to restrain an electric car approaching at high velocity, is sufficient cause in itself to condemn the use of this type of structure upon a thoroughfare of such importance as the Portland Bridge.

As an offset to the additional expense required for the construction of a bascule span, it has all of the advantages which are not afforded by the swing draw. It is quickly operated, the suggested draw being designed to open and close in from forty (40) to sixty (60) seconds; it affords an unobstructed channel of any desired width; without incurring any expense for ornamentation, but depending entirely upon the structural lines, a bascule bridge can be designed to conform with an appurtenant structure of any type; and last, but most important, the roadway traffic is protected against any possible danger when the draw is open, for in addition of the protective gates and warning signals provided on a swing type of structure, the bridge itself imposes a substantial bulkhead of sufficient strength to prevent any uncontrolled car or vehicle from breaking through.

Sheets Nos. 9 and 11 give a general and detailed illustration of the recommended draw-span, and Plate XI shows the appearance of an open lift bridge similar to the design presented herewith. For comparison we have inserted Plate XII showing the present Portland swing draw bridge.

The design presented does not contemplate the use of any of the many patented types of lift bridges now being exploited, the more important of which are the Scherzer Rolling Lift, the Strauss Trunnion, the Page and the Rall bascules. On general principles we do not advocate the selection of any patented devices for a structure of this magnitude and description, reasoning that such patents cannot cover the basic principles of the lift bridge, as it is almost as old as civilization itself, and the payment of royalties must necessarily be made on some special attachment that may or may not be meritorious, while the patent rights naturally carry with them a certain amount of restriction against competitive bidding that is likely to materially increase the cost without returning a proportionate gain.

We have estimated upon the construction of a trunnion type, double leaf bascule, with the counterweights concealed in chambers provided in the foundations, the trunnions to be heavy hollow steel forgings resting in roller bearings, the counterweights to be attached to the rear end of the trusses and to be so disposed that the leaves will be equally balanced in all positions.

Segmental cut steel gears are attached to the counterweight ends of the trusses, intermeshing with cut steel pinions keyed to a forged steel shaft which is extended into a motor room provided in the foundations at both ends of each bascule pier. Four (4) forty (40) horsepower motors are backgeared to the above described pinion shafts, two to each bascule leaf. A single motor has sufficient capacity to handle one leaf, but second motors are provided for emergency to insure certainty of operation. Four (4) three (3) horsepower motors are provided in the equipment chambers for operating the rail and truss locks that are thrown into position when the bridge is closed. These motors will also open and close the guard gates and operate the signals. Controllers for operating the entire bridge are provided in the towers on both ends of the draw-span, with connection wiring so arranged that the entire operation of the bridge can be controlled from either tower. Automatic devices are provided which will prevent throwing the large motors into service until the small motors have performed their duty; that is, have closed the guard gates, displayed the signals and unlocked the bridge. Conversely, the three (3) horsepower motors cannot operate until the bridge is fully closed.

To attain absolute certainty of operation three (3) sources of electric energy should be provided:—

First: Connection with the lines of the public service corporation.

Second: A gasolene engine with an electric generator should be installed ready for use in case of interruption on the public service lines.

Third: A storage battery should be provided for use in case both of the above are out of service.

Heavy steel pistons filled with oil act as buffers for absorbing the shock due to the sudden opening and closing of the bridge; these pistons are so arranged that the velocity of the moving leaves will be retarded, bringing the bridge to rest slowly without injury.

Obviously the moving bascule span should be constructed as lightly as possible; therefore, the framework for this construction must be entirely of steel unprotected by any coating other than paint, as no other material could be applied which would be certain to adhere to the structure owing to the constant vibration to which it is subjected. In keeping with the above reasoning, the floor of the bascules consists of two (2) layers of yellow pine plank, treated with wood preservative.

The steelwork in connection with the draw-span construction and the balustrade railing on the harbor spans later described is the only exposed ironwork which must be protected by painting. While it is universally conceded by engineers that a proper paint is a certain protection for steel or ironwork not subjected to the action of injurious fumes or gases, they are also fully aware that it is difficult to keep such structures well painted. As an insurance against any excuse for neglecting to paint the exposed metal work, we recommend the installation of a motor operated painting machine which will consist of a paint tank, an air compressor, a motor and a few feet of hose with a spray nozzle; the air compressor to be used for the double purpose of running the paint machine and as a blower to clean the electrical equipment in connection with the draw-span. We have previously stated that conduits will be laid in the balustrade railing for the lighting wiring, and by providing terminal boxes with plug receptacles in these conduits at frequent intervals the painting machine can be moved about on a small hand truck and be placed in operation at any desired point upon the bridge without difficulty. With such an apparatus no excuse can be offered for not keeping the exposed ironwork properly painted.

The foundations for the draw-span will be constructed in the following manner:—

Channels of the desired width and depth at the correct location of piers Nos. 10 and 11 will be excavated by dredging. Within the circumscribed limits of the pier outlines hardwood piles will be driven and cut off at the requisite elevation. While this work is in progress the large concrete caissons forming the base of the foundation piers will be constructed upon ways situated on the shore near the water edge. These caissons will be shells of reinforced concrete, braced with partition walls of the same material, with a horizontal timber diaphragm located approximately eight (8) feet from the bottom of the shell, upon which will be deposited a solid apron of concrete about five (5) feet thick. Through the concrete and timber diaphragm there will be provided four (4) or six (6) steel tubes four (4) feet in diameter, connecting the open spaces above and below the diaphragm, and projecting about two (2) feet above the apron concrete.

After the piling has been driven and sawed off, the steel tubes will be hermetically sealed, the caissons launched and towed into position over the piling and then sunk by filling the cellular interiors above the diaphragms with water. When accurately located, the caissons will be pumped out and air locks will be attached to the steel tubes, the space beneath the diaphragm forming a working chamber, permitting the excavation of the material around the top of the piles under compressed air, which will prevent the water from entering the chamber; the excavated material being hoisted through the air locks and deposited as filling in the cellular spaces on top of the concrete apron. The excavating in the working chamber will be continued around the edges of the caissons until the tops have settled to the correct elevation, then the working chamber will be filled with mass concrete.

The application of the caisson method for constructing the pier foundations affords many advantages. The work is of sufficient magnitude, as will be noted by referring to the figures given in "General Statistics," Appendix II, to require an extensive equipment for mixing and handling the concrete in the caissons alone. It is obvious that the plant can be operated and that the entire work can be performed much more economically and expeditiously upon dry land than it could possibly be done if the foundations are built in place surrounded by water, with all materials and apparatus handled upon lighters and scows. With the latter method extensive and expensive coffer dams must be constructed to permit the unwatering of an area sufficient to provide working room, if the foundations are to be built with an absolute knowledge as to the character of the footings; unless dependence is placed upon the indeterminate quality of the concrete which will be produced if it is deposited through water, or upon the possible ineffectiveness of a portion of the piling if a crib or other type of caisson is sunk into position upon pile clusters that have not been subjected to a visual examination. If the cost for constructing the foundations in the manner recommended was equal to that for the less certain methods above described, there would be sufficient argument to warrant the adoption of the compressed air caissons.

Above the caissons will be constructed the reinforced concrete cellular structures, with spaces provided to accommodate the operating apparatus, comprising the bascule trunnions, counterweights, etc. To secure adequate space for this equipment, semi-circular chambers, as shown on Sheet No. 11, are extended beyond the clear width of the bridge at each end of the bascule piers Nos. 10 and 11.

Above one semi-circular foundation chamber on alternate sides of the bascule piers Nos. 10 and 11, there is provided a bartizan or keeper's tower, rising above the level of the roadway, located on the pier ends overlooking the right hand harbor approaches. These bartizans consist of a plain reinforced concrete wall or pylon, facing the roadway of the bridge, presenting a smooth facade free from protrusions that will interfere with the bascule leaves when they are open. The rear facade, or water side, of the bartizans are semi-circular towers of granite, abutting against the rear of the concrete pylons, as shown on the Draw-span detail, Sheet No. 11. A doorway is provided at the roadway level for entering these operating towers. The operating room floor level is approximately twenty-five (25) feet above the elevation of the roadway. A pile fender, as shown on Sheets Nos. 9 and 11, must be provided on each side of the draw-span channel.

The semi-circular equipment chambers and the bartizans are the only parts of the entire bridge where any expense has been incurred to secure the desired artistic effect; but for these prominent members a distinctive architectural treatment is actually necessary, and the details of the ornamentation, illustrated on Sheet No. 11, are briefly as follows:—

The semi-circular concrete walls of the equipment chambers up to the bridge floor level are grooved and tooled. Rest seats of concrete or granite are provided within the semi-circular sidewalk spaces over the equipment chambers opposite the operating towers. The roadway facades of the towers are of tooled concrete, treated with flush tile inserts to relieve the color monotony. The semi-circular, or harbor, facades of the operating towers above the level of the roadway are constructed of cut granite with red tile roofs.

HARBOR SPANS.

The general appearance of the harbor spans, comprising that section of the bridge between pier No. 11 and the abutment for the South Portland approach, is shown on the West Elevation, Sheet No. 9, and in more detail on Sheet No. 10.

We consider that the foundations for the piers Nos. 12, 13 and 14 can be most economically constructed by employing the caisson method, constructing the concrete shells upon land and floating them into position, as described in detail in the preceding section for the draw-span foundations, for these piers should be of sufficient depth to permit the future excavation of the channel without their becoming undermined, because they are situated outside of the bulkhead line established by the United States Government. Pier No. 15 will be constructed behind a coffer dam with the open excavation methods previously described for the Commercial Street viaduct footings.

Five (5) one hundred and sixty (160) feet spans appears to be the most economical arrangement for the harbor spans, extending from the most southerly draw-span pier No. 11 for a total distance of eight hundred (800) feet to the South Portland approach. It may prove advisable when more time is available for detailed study to consider the extension of this construction for one or more spans toward the South Portland shore, but this is a matter which can be determined only by comparing carefully detailed estimates. The roadway grade at elevation fifty-four (54.), as will be noted by reference to the West Elevation, Sheet No. 9, has been continued to pier No. 14, the slope to South Portland commencing at this point, and the two southerly harbor spans are slightly inclined to meet the approach grade.

The main supporting members for the harbor spans consist of two (2) three (3) hinged reinforced concrete arches projecting above the roadway and passing through same at the quarter points of the span. The central floor system is supported by concrete encased steel suspenders hung from the arch rings. The entire design of the harbor span superstructure has been conceived with the intention of eliminating all shoring or falsework, the method of erection being as follows:

After the foundation caissons are in position, the concrete piers will be completed to the roadway level and the steelwork for the section of the main arch members below the roadway level will be erected, together with the steelwork for the floor system over this section, the entire construction being cantilevered from the piers. The end hinges of the arch rings are located approximately at the roadway level, and after the cantilever sections above described are erected the structural steel reinforcing for the arch rings, which will have been in process of fabrication on shore while the work on the cantilivers was progressing, will be floated into position on scows and lowered onto the fixed halves of the hinges supported on the ends of the cantilevers. The end thrust from the arches will be held with ties in the floor system.

The arch reinforcing will be designed of sufficient strength to support its own dead weight and the concrete casing which will be applied as soon as the steelwork is in position, and the remainder of the superstructure will be completed after the concrete arch rings have hardened.

The flooring will be a reinforced concrete slab laid over steel beams, with a wood block paving laid on a sand cushion and granolithic sidewalks.

When a span is entirely completed, the beams and stringers of the floor system will be wrapped with metallic lath and encased with cement plaster, applied with a cement gun operated from a platform on a scow anchored beneath the bridge. When the plaster casing is completed there will be no exposed steelwork to deteriorate, with the exception of the sidewalk railings.

To prevent injury to the caisson concrete from frost action, all of the piers subjected to tidal fluctuations, comprising piers Nos. 9 to 15 inclusive, will be veneered with a granite facing, extending from a level two (2) or three (3) feet below the elevation of mean low tide to a corresponding distance above mean high tide, this facing to be laid and bonded to the caisson concrete on shore for those piers which are to be floated into position.

SOUTH PORTLAND APPROACH.

Following the logic presented under the heading of "Design" in regard to the durability of engineering materials, we have planned on constructing that section of the bridge designated herein as the South Portland Approach entirely of earthwork, rip-rapped with large stones on the slopes for a sufficient height to preclude damage from tidal erosion; providing an inclined reinforced concrete retaining wall, faced with granite veneer between the tide limits, to hold the embankment and for an abutment to receive the end of the south harbor span.

It is contemplated that this fill can be made by the hydraulic method with material dredged from the harbor and deposited in place by water, augmented with a supply of dry earth or gravel deposited from the land end; the surplus water from the fill to be drained off through weeper pipes laid at frequent intervals in the body of the embankment. This is a method which has been very successfully adopted for similar embankments, and with our present knowledge there appears to be no obstacle against its use in this particular location. The fill will be one thousand and forty-five (1,045) feet long, with the top sloped on a uniform grade of two and one-half (2½) per cent. from the abutment to B Street in South Portland.

The estimates include the construction of a six (6) inch concrete paving slab with two (2) seven (7) feet wide granolithic sidewalks, guarded by artificial stone or concrete balustrades of the same design as employed for the Portland approach and the Commercial Street viaduct.

The conditions in South Portland are much less obstructive to the providing of an adequate approach than those existing on the Portland end, and the City of South Portland should ultimately plan to make the improvements to its approach in accordance with the general scheme indicated by the "dot" and "dash" lines on Sheet No. 10; relocating Ocean Street so that it will extend in a straight line from the new bridge to a new square adjacent to the present school house triangle, making provision in this square for the diversion of two arterial highways, one leading to an avenue, or boulevard, turning east from the proposed square and girting the entire shore line of South Portland, the other proceeding approximately south into the interior. The width of Ocean Street from the bridge to the contemplated square should be not less than eighty (80) feet. While it is not necessary to provide this ideal approach at present, Ocean Street is now altogether too much restricted, and with the volume of traffic which will patronize the new bridge shortly after its completion the existing conditions will be materially aggravated. Therefore, we strongly urge that immediate steps be taken to secure the land necessary for the consummation of the South Portland improvements to guard against the construction of private work which may interfere or obstruct the final location of the right of way on the general lines which we have proposed.

PROPERTY DAMAGE.

The property which must be condemned for the construction of the Portland end of the bridge is stipulated in the section on the "Portland Approach." The assessed value of this property is fifty-five thousand dollars ($55,000.00), including that which must be acquired on Commercial Street, an amount which seems high considering the location and the character of the buildings; but we have increased this amount by forty (40) per cent., making the total charge for property on the Portland side seventy-seven thousand dollars ($77,000.00).

The new bridge will interfere to some extent with the dockage of vessels at the old westerly coaling wharf owned by the Portland Terminal Company, but it will not be difficult to make the few changes necessary to remedy this condition.

It has been stated herein that the increase in the value of the property adjacent to the new bridge will be sufficient to yield an abundant return on the investment made to procure the property required for the Portland approach in less than twenty (20) years. This statement is based upon the actual results accruing from similar improvements made in other cities, and it is applicable to the property on the South Portland end of the bridge.

The total assessed value of the property which must be taken to complete the South Portland approach in accordance with the recommendations in this report does not exceed twenty thousand dollars ($20,000.00), and by increasing this assessed value by fifty (50) per cent. the initial cost chargeable to the bridge should not exceed thirty thousand dollars ($30,-000.00). If the property necessary for the relocation of Ocean Street and the construction of the square, described in the preceding section, is to be acquired at this time, the real estate cost will exceed the above amount, but any expenditure on this account should not be charged to the cost of the bridge, as it is for an improvement not directly related to the South Portland approach proper.

ESTIMATES.

The attached Appendix I contains an itemized statement of the unit quantities and prices for the several divisions of the bridge, from which were derived the totals presented in this section.

The figures given in this itemized estimate must be used with discretion when comparisons are made with known local unit prices for the cost of similar construction work. First of all must be remembered the magnitude of the operations involved in the construction of this bridge which makes it practical to use the most approved contractors' apparatus for the handling, preparation and placing of the several materials.

To illustrate:—The total volume of the concrete will be approximately fifty thousand (50,000) cubic yards, requiring the quarrying and crushing of forty-five thousand (45,000) cubic yards of stone, a single operation sufficient in itself to warrant the construction of a complete stone crushing plant upon some convenient island where an abundant supply of suitable rock may be secured; and, in addition, there will be required the large quantity of rock for the rip-rap paving on the slopes of the South Portland approach embankment. Without entering into further detailed description it is sufficient to state that the same wholesale methods must be pursued for all of the work in connection with the new bridge.

It is customary to estimate concrete upon the basis of the cost per cubic yard in place, including in such estimates the cost of materials, labor for preparation, labor for placing and the forms, which in turn include lumber and labor, and while this method may be sufficiently accurate for ordinary propositions, it does not give correct results when applied to heavy construction work. For such work it is necessary to consider each item entering into the cost for a unit of material in place. For example:—To determine the average cost per cubic yard of concrete in the Portland approach, as given in Division I of the estimate, requires the following procedure:—

Under the heading "Unit Cost" the concrete for the York Street retaining wall is estimated at five dollars and sixty cents (5.60) per cubic yard; New Street, five dollars and twenty cents ($5.20); Abutment, five dollars and twenty cents ($5.20), the grand total summing up to nineteen thousand seven hundred and sixty dollars ($19,760.00). These unit prices include only the crushed rock, the cement and the sand, with the labor for mixing and placing.

Under the same heading, Section 3, "Forms," the cost for labor per square foot of forms has been estimated at six cents ($0.06) for all of the concrete work comprised under Item 2, and, in addition, a total of one hundred and fifty thousand (150,000) feet, board measure, of lumber has been estimated at twenty-seven dollars ($27.00) per thousand, making the total for forms alone eight thousand three hundred and ten dollars ($8,310.00), and the total net cost for the concrete in the Portland approach twenty-eight thousand and seventy dollars ($28,070.00).

Items 11 and 12 in the same estimate division contain the contingency allowance and the contractor's profit respectively, which must be added to the above twenty-eight thousand and seventy dollars ($28,070.00) to obtain the total which it is estimated must be paid by the purchaser for the above concrete, or a sum of thirty-two thousand four hundred and twenty dollars ($32,420.00), making the unit price for the two thousand seven hundred (2,700) cubic yards of concrete (the summation of the quantities for Section 2) practically twelve dollars ($12.00) per cubic yard; and the same summation process must be used to determine the estimated unit costs to the purchaser for all materials in place, always bearing in mind that the unit costs as given are the subdivided net costs to the contractor and not the cost of the work to the purchaser.

The estimate can be relied upon for accuracy on the premises which have been established in regard to the foundations, design and construction as described herein, and it includes the entire cost, unless litigation imposes an unanticipated expense.

The cost of the work we estimate to be as follows:

Portland Approach	$87,300 00
Commercial Street Viaduct	237,530 00
Draw-span	338,335 00
Harbor Spans	247,364 00
South Portland Approach	104,669 00
Real Estate, Portland	77,700 00
Real Estate, South Portland	20,000 00
Borings	10,000 00
Interest on Investment during const.	45,316 00
Total	$1,178,214 00

While it may be possible upon entering into the refinements of design to somewhat reduce the above figures, we do not consider that it would be advisable to state at this time that the bridge can be built for less than one million two hundred thousand dollars ($1,200,000.00).

The accuracy of the estimate can be substantially verified by comparing the costs given for the new bridge with the actual costs of similar structures, taking into consideration the important factors that would modify the conditions, in order that the comparisons may be made upon an equitable basis. In Appendix II statistics are given regarding the dimensions and cost of the Vaughans Bridge in Portland and the Division Street bascule bridge in Chicago.

The Vaughans Bridge has a total length of one thousand three hundred and fourteen (1,314) feet and a maximum roadway height of sixteen and eighty-three hundredths (16.83) feet above mean low tide, as against a total length of three thousand and one hundred and eleven (3,111) feet and a maximum roadway height of fifty-four (54) feet above mean low tide for the new Portland Bridge; the latter being more than one hundred and thirty-six (136) per cent. longer and more than two hundred and ten (210) per cent. higher than the Vaughans Bridge; but the cost per lineal foot of bridge is practically the same for each, or three hundred and seventy-nine dollars ($379.00) for the Portland Bridge and three hundred and eighty dollars ($380.00) for the Vaughans Bridge, while the estimated cost per square foot of the former is six dollars and thirteen cents ($6.13), or eleven (11) per cent. less than the six dollars and ninety cents ($6.90) paid for the latter.

The excessive cost of the Vaughans Bridge was largely due to foundation difficulties, but it should not be forgotten that the bridge probably cost less than it would had the contractors made a profit instead of losing money on the proposition; although it is probable that the work could have been executed more economically if complete detailed plans and specifications had been prepared by an engineer before the project was submitted to the contractors for competitive figures.

The Division Street bascule bridge cost about one hundred and sixty thousand dollars ($160,000.00) for the superstructure, with a span of one hundred and seventy-two (172) feet and eight (8) inches between the centers of trunnions and a width of sixty (60) feet. The contemplated Portland Bridge bascule has a span of two hundred and twenty (220) feet center to center of trunnions, or a length about twenty-seven (27) per cent. longer than the Division Street bridge, and a width of sixty-two (62) feet. As the draws are both cantilevers, the relative costs for the structural work, other things being equal, should be directly proportional to the lengths and breadths, but the cost of mechanism and equipment for the longer span will not be much greater than will be required for the shorter; hence, the unit cost per square foot for the Division Street Bridge should be materially more than that for the Portland Bridge, especially as our estimates do not contemplate any expenditure for patent rights. The estimated cost for the Portland draw-span superstructure is about one hundred and fifty thousand dollars ($150,000.00), or approximately eleven dollars and fifty cents ($11.50) per square foot, and the cost for the Division Street superstructure is one hundred and sixty thousand dollars ($160,000.00), or about fifteen dollars and fifty cents ($15.50) per square foot.

As the foundations for the two bridges are of the same general character, the relative costs should be nearly proportional to the difference in height, and on this basis the Portland Bridge substructure, ninety (90) feet high, should cost about ninety-fortieths (90/40) of ninety-four thousand dollars ($94,000.00), or approximately two hundred and ten thousand dollars ($210,-000.00), a figure which appears to verify the estimated cost of one hundred and eighty-eight thousand dollars ($188,000.00).

The foregoing comparison indicates that the design as conceived is economical and that it is within the bounds of reason to assume that the Portland Bridge should be constructed within the limits of the estimate and still be an edifice adapted to its environments.

ANNUAL CHARGES.

The following figures show the total amounts which must be set aside and expended each year for "fixed" and "operating" charges. The annual fixed charges are based upon the assumption that the *entire* cost of the bridge will be paid with the proceeds from a fifty (50) year three and one-half (3½) per cent. bond issued, and on this basis sufficient sums are provided in the form of sinking funds to keep the bridge in first-class physical condition until the bonds are retired; if only a portion of the cost is paid by the bond sale receipts, the total fixed charges will be proportionately reduced.

The items given for operating charges are self-explanatory; the amounts being based upon recorded local and other costs.

Fixed Charges.

Interest on Investment of $1,178,-000.00 @ 3½%	$41,230 00	
Sinking Fund, invested @ 2½% to retire bond issue in 50 years, $1,-178,000.00 @ $10.26 per M	12,086 00	
Depreciation, Concrete Superstructure, sinking fund to replace $208,000.00 in 70 years, invested @ 2%, $6.67 per M	1,387 00	
Depreciation, Exposed Steelwork and Machinery, sinking fund to replace $92,000.00 in 20 years, invested @ 3½%, $35.36 per M.	3,253 00	
Depreciation, Superstructure, Harbor Spans, sinking fund to replace $118,000.00 in 50 years, invested @ 2½%, $10.26 per M	1,211 00	
	$59,167 00	
Total Fixed Charges		$59,167 00

Operating Charges.

Electric Power	$500 00
Electric Lights for Bridge and Approaches (114-60 c. p. @ $25.00)	2,850 00
Bridge Tenders	1,500 00
Cleaning Bridge, $0.10 per sq. yd.	1,590 00

Painting exposed steelwork every 2 yrs.	275 00	
Paving Repairs	2,500 00	
Machinery Repairs	1,150 00	
	$10,365 00	
Total Operating Charges		$10,365 00
Total Annual Charges		$69,532 00

CONCLUSION.

Finally we wish to call attention to a phase of the situation which is the factor of vital importance that must be considered before determining whether or not there is immediate need for definite action in regard to the construction of a new bridge; this is the time which must elapse before a new bridge can be opened to the public, and during which period the present unsafe and inadequate structure must be kept in service.

Should immediate steps be taken toward the construction of the new bridge, it is improbable that the work could be completed prior to 1916; for at least three months should be allowed in which to secure complete borings over the several locations that might be finally considered, including borings on York Street to determine the contour of the ledge, if the Portland approach is to be built in accordance with our recommendations. After the borings are finished at least six months should be allowed for the preparation of complete plans and specifications, preferably this time should be extended to nine months, as the first two or three months prior to the preparation of detailed plans should be devoted to study sketches and estimates, if a bridge having a minimum first cost is to be built.

When the plans and specifications are completed, at least one month should be allowed the contractors for the preparation of their estimates and proposals. This time is not required on account of the superstructure, for it is the simplest part of the entire work and the new bridge is not a problem of steel fabrication; but it is one of deep water foundations, necessitating the application of the most expert engineering knowledge and practical experience of the highest order for the determination of the probable costs upon which the contractors' proposals must be based. The balance of the intervening period between the present date and 1916 will, therefore, afford none too much time for the completion of the work, for at least two years should be allowed for the actual construction period.

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TABLE I.

TABULATION SHOWING THE GROWTH OF TWENTY-THREE AMERICAN CITIES FROM 1880 TO 1910. FROM CENSUS OF 1910.

	1		2	3	4	5	6	7	8
	City		Population				Per Cent. Increase		
			1880	1890	1900	1910	1880 to 1890	1890 to 1900	1900 to 1910
1	Akron	Ohio	16,512	27.601	42.728	69,067	67.2	54.8	61.0
2	Altoona	Pennsylvania	19,710	30,337	38,973	52,127	53.9	28.5	33.5
3	Bridgeport	Connecticut	27,643	48,866	70,996	102.054	76.8	45.3	43.8
4	Covington	Kentucky	29,720	37,371	42,938	53.270	25.7	14.9	24.0
5	Elizabeth	New Jersey	28,229	37,764	52,130	73,409	50.4	15.5	40.7
6	Erie	Pennsylvania	27.737	40,634	52,733	66,525	46.5	29.8	26.1
7	Evansville	Indiana	29,280	50,756	59.007	69,647	73.3	16.3	18.0
8	Fort Wayne	Indiana	26,880	35,393	45,115	63,933	31.7	27.5	41.6
9	Hoboken	New Jersey	30,999	43,648	59,364	70,324	40.8	36.0	18.4
10	Lancaster	Pennsylvania	25,769	32,011	41,459	47,227	24.2	29.5	13.8
11	Lawrence	Massachusetts	39,151	44.654	62.559	85,892	14.1	40.1	37.1
12	Lynn	Massachusetts	38,274	55,727	68,513	89,336	45.6	22.9	30.0
13	Manchester	New Hampshire	32.630	44,126	56,987	70,063	35.2	99.1	22.9
14	New Bedford	Massachusetts	26,845	40,733	62,442	96,652	51.7	53.3	54.6
15	Oakland	California	34,555	48,682	66,960	150,174	40.9	37.5	125.0
16	Peoria	Illinois	29,259	41,024	56.100	66,950	40.2	36.7	19.3
17	PORTLAND	MAINE	33,810	36,425	50.145	58,571	7.7	37.7	16.6
18	Quincy	Illinois	27,268	31,494	36,252	36,587	15.5	15.1	1.0
19	Salem	Massachusetts	27,563	30,801	35,956	43,697	11.7	16.7	21.4
20	Savannah	Georgia	30.709	43,189	54,244	65,064	40.6	25.6	20.0
21	Somerville	Massachusetts	24,933	40,152	61,643	77,236	61.0	53.5	25.0
22	Springfield	Massachusetts	33,340	44,179	62,059	88,926	32.5	40.5	43.2
23	Utica	New York	33,914	44,007	56,383	74,419	29.8	28.1	31.8
	Totals		674,730	929,574	1.235,686	1,671,150	*37.6	*33.0	*35.0

* From totals of Columns Nos. 2, 3, 4, and 5.

Average increase in 160 American Cities, exceeding 25,000 population. 150.1 39.3

Note:—The Census of 1900 shows 161 cities in the United States having at least 25,000 population, and only 5 per cent. of these show a lower percentage of growth than Portland.

TABLE II.

RELATION OF POPULATION, WAGE EARNERS AND CAPITALIZATION OF INDUSTRIES TO HORSEPOWER IN TYPICAL NEW ENGLAND CITIES FROM CENSUS OF 1910.

1	2	3	4	5	6	7	8	9	10
Cities	Primary H. P.	Wage Earners	Wage Earners Per H. P.	Population Total	Per H. P.	Value added by Industries Total	Per P. H.	Capitalization Total	Per H. P.
MAINE									
Portland	7,849	5,209	.66	58,571	7.5	$5,941,380	$760 00	$9,596,967	$1,220 00
Auburn	3,445	3,776	1.1	15,064	4.4	3,052,792	890 00	4,084,993	1,180 00
Lewiston	19,438	6,887	.35	26,247	1.35	5,200,491	270 00	12,639,103	650 00
Augusta	5,350	2,176	.41	13,211	2.5	2,177,989	410 00	3,414,469	640 00
Biddeford	17,038	5,257	.31	17,079	1.0	4,114,144	240 00	7,172,156	420 00
Total	53,120	23,305	*.44	130,172	*2.46	20,486,746	*386 00	36,907,688	*695 00
MASSACHUSETTS									
Holyoke	60,269	17,417	.29	57,730	.96	17,796,637	295 00	42,674,771	710 00
Lawrence	73,066	30,747	.42	85,892	1.17	34,554,606	475 00	79,550,475	1,085 00
Lynn	17,089	29,508	1.73	89,336	5.2	30,142,053	1,765 00	42,784,070	2,500 00
New Bedford	76,147	27,340	.36	96,652	1.27	24,674,271	325 00	58,970,015	775 00
Total	226,571	105,012	*.464	329,610	*1.45	107,167,567	*474 00	223,979,331	*990 00
NEW HAMPSHIRE									
Manchester	61,796	25,301	.41	70,063	1.13	16,314,820	264 00	26,220,942	425 00
Berlin	25,537	1,854	.073	11,780	.46	2,242,266	88 00	13,050,880	510 00
Total	87,333	27,155	*.31	81,843	*.94	18,557,086	*213 00	39,271,822	*450 00
NEW YORK									
Lockport	14,335	2,138	.15	17,970	1.25	2,818,000	197 00	10,227,000	715 00
Niagara Falls	95,792	6,089	.064	30,445	.32	14,381,000	150 00	37,239,000	390 00
Rochester	39,277	41,865	1.07	218,149	5.5	62,001,833	1,580 00	95,707,791	2,440 00
Total	149,404	50,092	*.336	266,564	*1.78	79,200,833	*530 00	143,173,791	*960 00
Average of above Cities	36,887	14,683	.398	57,728	1.56	16,100,874	437 00	31,666,616	860 00

*Average from Totals

TABLE III.

TABULATION SHOWING THE GROWTH OF POPULATION IN PORTLAND, SOUTH PORTLAND AND CAPE ELIZABETH.

Year		Portland	Per cent increase	Cape Elizabeth	Per cent increase	South Portland	Per cent Increase	Combined Population	Per cent increase		Accelerated Growth	Per cent increase	Average 23 cities 35% increase
1790		2,246											
1850		22,815	915.0	2,082				24,897					
1860		26,341	15.45	3,278	57.0			29,619	19.0				
1870		31,413	19.25	5,106	56.0			36,519	23.0				
1880	*	33,810	7.65	5,302	4.0			39,112	7.0	§			
1890		36,425	7.74	5,459	3.0			41,884	7.0				
1900		†50,145	37.75	‡ 887		6,287		57,319	37.0				
1910		58,751	16.8	1,857		7,471	18.8	68,079	19.0		68,079		68,079
1920		69,000	17					80,000	17		100,000	17% +20,000	92,000
1930		80,500	17					93,000	17		137,000	17% +20,000	124,000
1940		94,000	17					109,000	17		180,000	17% +20,000	167,000
1950		110,000	17					128,000	17		210,000	17%	226,000
1960		129,000	17					149,000	17		246,000	17%	305,000

* 17.44% average each 10 years.

§ Average, 18.7%.

† February 6, 1899, Deering annexed.

‡ March 15, 1895, South Portland separated from Cape Elizabeth.

TABLE IV.

TABULATION OF TRAFFIC THROUGH DRAWBRIDGE.

	Jan.		Feb.		March		April		May		June	
	Vessel	Opening	Vessel	Opening	Vessel	Opening	Vessel	Opening	Vessel	Opening	Vessel	Opening
1906												
*Vessels	62	62	59	55	62	63	85	85	96	96	76	74
Scows	2	2	0	0	1	1	1	1	8	8	108	108
Motor Boats	8	8	0	0	1	1	0	0	0	0	0	0
Tugs	228	105	199	92	201	107	176	88	228	109	370	178
Total	300	177	258	147	266	172	262	174	332	213	554	360
1907												
*Vessels	45	45	51	50	68	67	70	69	73	72	66	64
Scows	13	13	2	2	3	3	17	15	184	171	200	189
Motor Boats	0	0	0	0	0	0	1	1	0	0	0	0
Tugs	216	108	238	134	192	105	268	149	592	227	573	298
Total	274	166	291	186	263	175	356	234	849	470	839	551
1908												
*Vessels	102	97	67	66	95	94	68	68	61	59	72	69
Scows	212	92	95	90	148	135	226	216	64	60	50	48
Motor Boats	0	0	0	0	0	0	0	0	0	0	2	2
Tugs	561	190	376	160	481	155	569	161	275	91	451	158
Total	875	379	538	316	724	384	863	445	400	210	575	277

	July		Aug.		Sept.		Oct.		Nov.		Dec.		Totals		Total Opening for Tugs, Scows, Etc.
	Vessel	Opening	Vessel	Opening	Vessel	Opening	Vessel	Opening	Vessel	Opening	Vessel	Opening	Vessel	Opening	
1906															
*Vessels	42	42	57	57	47	38	40	36	56	54	52	52	735	714	
Scows	208	200	179	167	193	183	141	138	98	94	103	101	1,040	1,003	
Motor Boats	0	0	0	0	0	0	0	0	2	2	0	0	11	11	
Tugs	471	197	512	205	529	190	441	192	417	198	525	270	4,927	1,932	
Total	721	242	748	429	769	411	622	368	573	348	680	423	6,713	3,660	2,946
1907															
*Vessels	75	73	114	112	95	93	82	82	66	66	85	79	890	872	
Scows	248	229	336	305	263	236	182	170	122	114	260	137	1,830	1,584	
Motor Boats	0	0	0	0	0	0	0	0	2	2	3	3	4	6	
Tugs	730	287	786	203	701	232	483	119	407	150	500	253	5,686	2,265	
Total	1053	589	1236	620	1059	561	647	371	597	332	848	472	8,410	4,727	3,855
1908															
*Vessels	69	68	57	55	53	52	46	44	42	42	61	59	793	773	
Scows	87	80	143	135	68	63	3	3	0	0	2	2	1,098	924	
Motor Boats	2	2	0	0	0	0	0	0	2	2	0	0	6	6	
Tugs	405	151	421	161	252	100	158	70	178	91	145	114	4,272	1,602	
Total	563	301	621	351	373	215	207	117	222	135	208	175	6,169	3,305	2,532

TABLE IV—*Concluded.*

1909																											
*Vessels	32	30	35	35	37	36	48	48	47	44	72	72	77	77	58	56	36	36	53	53	36	36	28	28	559	551	
Scows	23	23	3	3	2	2	0	0	0	0	0	0	0	0	12	12	4	4	2	2	2	2	4	4	52	52	
Motor Boats	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	
Tugs	155	62	132	56	137	53	165	76	194	81	206	80	261	111	200	97	115	55	172	75	150	78	139	42	2,026	866	
Total	210	115	170	94	176	91	215	126	241	125	278	152	338	188	270	165	155	95	227	130	188	116	171	74	2,639	1,473	922
1910																											
*Vessels	29	29	39	39	53	53	31	31	50	48	109	109	91	89	76	76	62	62	60	60	71	71	41	41	712	708	
Scows	0	0	0	0	4	4	2	0	0	0	0	0	2	1	5	4	109	108	0	0	0	0	5	5	127	121	
Tugs	81	52	148	66	203	73	93	34	144	64	153	60	116	69	154	55	294	90	177	70	130	61	157	70	1,850	764	
Total	110	81	187	105	260	130	126	65	194	112	262	169	209	159	235	135	465	260	237	130	201	132	203	116	2,689	1,596	888
1911																											
*Vessels	48	46	39	38	40	40	33	32	48	48	65	65	65	65	71	71	70	69	61	59	53	51	42	42	635	626	
Scows	4	4	0	0	1	1	0	0	3	3	2	2	30	30	131	128	67	66	2	2	2	2	4	4	246	242	
Tugs	151	80	110	58	133	66	131	74	138	54	164	64	212	80	387	156	286	102	156	53	168	81	147	77	2,183	945	
Total	203	130	149	96	174	107	164	106	189	105	221	131	307	175	589	355	423	237	219	114	223	134	193	123	3.064	1,813	1,187
1912																											
*Vessels	41	40	20	20	36	35	47	47	45	43	52	51	51	51	54	52	84	84	75	75	63	61	57	57	625	617	
Scows	0	0	0	0	0	0	3	3	8	8	0	0	4	4	2	2	6	6	2	2	9	9	11	11	45	45	
Tugs	143	66	78	30	124	50	140	60	142	56	171	76	117	42	139	53	215	82	196	97	187	83	169	73	1,821	768	
Total	184	106	98	50	160	85	190	110	195	107	223	127	172	97	195	108	305	172	273	174	259	153	237	141	2,491	1,430	813

*Craft with masts

TABLE V.

TABLE OF STRESSES—EAST TRUSS.

1	2	3	4	5	6	7
Member.	Range of Stress.		Yield Point.		Actual Unit Stress.	Factor of Safety Sound
	Tension	Compress	Tension	Compress		
End Post..............Lo-U1	— 4,900	+84,350	30,000	24,350	+ 9,000	2.7
Top Chord............U1-U3	—15,550	+90,875	30,000	25,870	+ 9,700	2.7
" " U3-U5	—55,200	+72,250	30,000	25,870	+ 7,700	3.36
" " U5-U6	—96,500	......	30,000	22,080	— 7,800	3.85
Top Chord Links.....U6-L6'	—69,500	None	30,000		— 5,000	6.0
Bottom Chords........Lo-L2	—64,765	+ 8,200	30,000	24,100	—12,500	2.4
L2-L4	—88,230	+42,600	30,000	25,440	—10,400	2.9
L4-L6	—41,000	+94,200	30,000	24,232	+ 7,900	3.7
L6-L6'	None	+100,900		25,537	+ 8,330	3.1
Diagonal..............U1-L2	......	......	30,000	21,790		
L2-U3	......	......	30,000			
U3-L4	......	......		23,500		
L4-U5	......	......	30,000			
U5-L6	None	+68,950		22,500	+ 6,450	3.5
Post L6-U6		......	30,000	22,740		
Hangers U1-L1	—34,850	None	30,000		—11,200	2.68
U3-L3	—34,850	None	30,000		—11,200	2.68
U5-L5	—34,850	None	30,000		—11,200	2.68
Verticals U2-L2	None	......		14,325		
U4-L4	None	......		13,200		
Upper Laterals.........O. K.						
Lower Laterals........O. K.						
F. B. Hangers.	—33,250	None	30,000		—10,900	2.75

TABLE V.

TABLE OF STRESSES—WEST TRUSS.

1	2	3	4	5	6	7
Member	Range of Stress		Yield Point		Actual Unit Stress	Factor of Safety Sound.
	Tension	Compress	Tension	Compress		
End Post..............Lo–U1	— 6,000	+82,600	30,000	24,350	+ 8,800	2.77
Top Chord U1–U3	—18,450	+88,925	30,000	25,870	+ 9,500	2.72
" " U3–U5	—64,700	+70,925	30,000	25,870	+ 7,500	2.26
" " U5–U6	—113,900	......	30,000		— 9,250	3.24
Top Chord Links.....U6–U6′	—84,500	None	30,000		— 6,000	5.0
Bottom Chords........Lo–L2	—63,465	+ 9,000	30,000	24,180	—12,200	2.46
L2–L4	—86,355	+48,500	30,000	24,180	—16,600	1.8
L4–L6	—39,930	+107,600	30,000	24,230	+ 9,100	2.66
L6–L6′	None	+115,900		25,537	+ 8,150	3-13
Diagonal U1–L1		......	30,000	21,790		
L2–U3		......	30,000			
U3–L4		......	30,000	23,500		
L4–U5		......	30,000			
U5–L6		+67,625		22,500	+ 6,300	3.6
Post L6–U6		......	30,000	22,740		
Hangers...............U1–L1	—32,700	None	30,000		—10,500	2.86
U3–L3	—32,700	None	30,000		—10,500	2.86
U5–L5	—32,700	None	30,000		—10,500	2.86
Verticals U2–L2		......		14,325		
U4–L4		.. .		13,200		
Upper Laterals						
Lower Laterals						
F. B. Hangers	—32,700	None	30,000		—10,700	2.8

TABLE VI.

STRESSES IN PRESENT DRAW-SPAN WITH FULL LOADING—EAST TRUSS.

Member.		Maximum Stress		Allowable ult. unit stress	Actual unit stress	Factor of safety if sound	Estimated per cent. sound	Estimated present factor of safety
		—Tension	+Compress					
End Post	Lo-U1	7,000	131,100	+23,380	+13,980	1.60	85	1.42
Top Chord	U1-U3	21,450	135,725	+23.020	+14,470	1.6	85	1.35
" "	U3-U5	74,300	107,275	+17,070	+10,370	1.65	90	1.48
" "	U5-U6	130,100	none	-30,000	-10,530	2.85	85	2.4
Top Chord Links	U6-U6′	99,400	"	-30,000	-7,100	4.2	100	4.2
Bottom Chords	Lo-L2	147,615	9,800	-28,500	-28,390	1.0	55	0.55
" "	L2-L4	130,640	54,400	-21,890	-15,460	1.42	50	0.71
" "	L4-L6	61,340	121,100	+16,964	+10,190	1.66	50	0.83
" "	L6 L6′		130,800	+25,537	+9,180	2.8	60	1.68
Diagonals	U1-L2	61,025	19,600	-24,000	-11,730	2.04	80	1.63
"	L2-U3	32,500	25,950	-30,000	-7,020	4.3	90	3.9
"	U3-L4	none	63,450	+23,500	+5,950	3.96	85	3.36
"	L4-U5	95,100	none	-30,000	-11,875	2.53	95	2.4
"	U5-L6	none	129,340	+22,500	+12,134	1.86	55	1.02
Post	L6-U6	2,870	43,400	+21,810	+2,450	8.9	85	7.6
Hangers	U1-L1	41,980	none	-30,000	-13,460	2.23	95	2.12
"	U3-L3	41,980	"	-30,000	-13,460	2.23	95	2.12
"	U5-L5	41,980	"	-30,000	-13,460	2.23	95	2.12
Vertical	U2-L2	none	1,600	+14,325	+550	26.0	100	26.0
"	U4-L4	"	1,600	+13,200	+410	26.0	100	26.0
Upper lateral system							90	o. k.
Lower " "							90	o.k.
Floor Beam Hangers		40,380	none	-30,000	-13,200	2.27	100	2.27.
Floor Plank			stringers	stressed	beyond			o. k..
Roadway Stringers			safe value	see	report			
Floor Beams								

TABLE VI.

STRESSES IN PRESENT DRAW-SPAN WITH FULL LOADING—WEST TRUSS.

Member		Maximum Stress		Allowable ult. unit stress	Actual unit stress	Factor of safety if sound	Estimated per cent. sound	Estimated present factor of safety
		—Tension	+Compress					
End Post	Lo-U1	8,000	144,650	+23,400	+15,500	1.51	85	1.28
Top Chord	U1-U3	24,150	150,200	+23,000	+16,000	1.44	85	1.22
" "	U3-U5	83,000	118,730	+16,900	+12,650	1.34	90	1.2
" "	U5-U6	145,400	none	-30,000	-11,800	2.54	85	2.15
Top Chord Links	U6-U6'	113,000	"	-30,000	-8,100	3.7	100	3.71
Bottom Chords	Lo-L2	108,450	10,500	-28,000	-20,850	1.34	50	0.67
" "	L2-L4	145,540	59,800	-23,000	-28,000	0.82	50	0.41
" "	L4-L6	63,650	133,300	+17,800	+11,200	1.59	50	0.79
" "	L6-L6'	none	144,400	+25,537	+10,100	2.53	80	2.0
Diagonals	U1-L2	65,250	22,000	-23,900	-12,500	1.91	80	1.53
"	L2-U3	36,900	Eye bar	-30,000	-8,200	3.66	90	3.3
"	U3-L4	8,500	69,440	+21,400	+6,500	3.3	85	2.8
"	L4-U5	106,590	Eye bar	-30,000	-13,300	2.25	95	2.15
"	U5-L6	none	132,000	+22,500	+12,400	1.81	95	1.72
Post	L6-L6	7,110	49,300	+20,500	+2,800	7.35	90	6.6
Hangers	U1-L1	49,200	none	-30,000	-15,750	1.9	95	1.8
"	U3-L3	49,200	"	-30,000	-15,750	1.9	95	1.8
"	U5-L5	49,200	"	-30,000	-15,750	1.9	95	1.8
Vertical	U2-L2	none	1,600	+14,325	+550	26.0	100	
"	U4-L4	"	1,600	+13,200	+410	32.0	100	
Upper lateral system							90	o. k.
Lower lateral system							90	o. k.
Floor beam hangers		47,600	none	-30,000	-15,500	1.93	90	1.74
Floor plank								o. k.
Sidewalk			Brackets	o. k.	Stringers	poor		
Roadway stringers			Badly	over-	stressed	See	r eport	
Floor beams				See	report			

TABLE VII.

Electric Car Schedule.

FURNISHED BY THE CUMBERLAND COUNTY POWER & LIGHT COMPANY.

Cars Leaving Portland for Knightville, Via Portland Bridge,

December 17, 1913. From 6.10 A. M. Until 11.30 P. M. Cape Division.

A. M.	Capacity	Truck	A. M.	Capacity	Truck	A. M.	Capacity	Truck	P. M.	Capacity	Truck
6.10	40 Pass.	Double	8.20	40 Pass.	Double	10.50	22 Pass.	Single	1.10	22 Pass	Single
6.10	40 "	"	8.30	40 "	"	11.00	40 "	Double	1.15	22 "	"
6.15	22 "	Single	8.30	40 "	"	11.10	40 "	"	1.20	40 "	Double
6.20	40 "	Double	8.40	40 "	"	11.10	40 "	"	1.30	40 "	"
6.30	40 "	"	8.45	22 "	Single	11.10	22 "	Single	1.30	40 "	"
6.30	40 "	"	8.50	22 "	"	11.15	22 "	"	1.40	40 "	"
6.40	40 "	"	8.50	40 "	Double	11.20	40 "	Double	1.45	22 "	Single
6.45	22 "	Single	9.00	40 "	"	11.30	40 "	"	1.50	40 "	Double
6.50	22 "	"	9.10	40 "	"	11.30	40 "	"	1.50	22 "	Single
6.50	40 "	Double	9.10	40 "	"	11.40	40 "	"	2.00	40 "	Double
7.00	22 "	Single	9.15	22 "	Single	11.45	22 "	Single	2.10	40 "	"
7.00	40 "	Double	9.20	40 "	Double	11.50	22 "	"	2.10	40 "	"
7.00	22 "	Single	9.30	40 "	"	11.50	40 "	Double	2.10	22 "	Single
7.10	40 "	Double	9.30	40 "	"	12.00	40 "	"	2.15	22 "	"
7.10	40 "	"	9.40	40 "	"	P. M.			2.20	40 "	Double
7.15	22 "	Single	9.45	22 "	Single	12.10	40 "	"	2.30	40 "	"
7.20	40 "	Double	9.50	22 "	"	12.10	40 "	"	2.34	40 "	"
7.30	40 "	"	9.50	40 "	Double	12.10	22 "	Single	2.40	40 "	"
7.30	40 "	"	10.00	40 "	"	12.15	22 "	"	2.45	22 "	Single
7.40	40 "	"	10.10	22 "	Single	12.20	40 "	Double	2.50	22 "	"
7.45	22 "	Single	10.10	40 "	Double	12.30	40 "	"	2.50	40 "	Double
7.50	22 "	"	10.10	40 "	"	12.30	40 "	"	3.00	40 "	"
7.50	40 "	Double	10.15	22 "	Single	12.40	40 "	"	3.10	40 "	"
8.00	40 "	"	10.20	40 "	Double	12.40	22 "	Single	3.10	40 "	"
8.00	22 "	Single	10.30	40 "	"	12.50	22 "	"	3.10	22 "	Single
8.10	22 "	"	10.30	40 "	"	12.50	40 "	Double	3.15	22 "	"
8.10	40 "	Double	10.40	40 "	"	1.00	40 "	"	3.20	40 "	Double
8.10	40 "	"	10.45	22 "	Single	1.10	40 "	"	3.30	40 "	"
8.15	22 "	Single	10.50	40 "	Double	1.10	40 "	"	3.30	40 "	"

TABLE VII.

ELECTRIC CAR SCHEDULE.

P. M.	Capacity	Truck	P. M.	Capacity	Truck	P. M.	Capacity	Truck	P. M.	Capacity	Truck
3.40	40 Pass.	Double	5.45	22 Pass.	Single	7.50	40 Pass.	Double	10.00	40 Pass.	Double
3.45	22 "	Single	5.50	22 "	"	7.50	22 "	Single	10.10	40 "	"
3.50	22 "	"	5.50	40 "	Double	8.00	40 "	Double	10.10	40 "	"
3.50	40 "	Double	6.00	40 "	"	8.10	40 "	"	10.15	22 "	Single
4.00	40 "	"	6.10	40 "	"	8.10	40 "	"	10.20	40 "	Double
4.10	40 "	"	6.10	22 "	Single	8.10	22 "	Single	10.30	40 "	"
4.10	40 "	"	6.10	40 "	Double	8.15	22 "	"	10.30	22 "	Single
4.10	22 "	Single	6.15	22 "	Single	8.20	40 "	Double	10.40	40 "	Double
4.15	22 "	"	6.20	40 "	Double	8.30	40 "	"	10.45	22 "	Single
4.20	40 "	Double	6.30	40 "	"	8.30	40 "	"	10.50	40 "	Double
4.30	40 "	"	6.30	40 "	"	8.40	40 "	"	10.50	22 "	Single
4.30	40 "	"	6.40	40 "	"	8.45	22 "	Single	11.00	40 "	Double
4.40	40 "	"	6.45	22 "	Single	8.50	22 "	"	11.10	40 "	"
4.45	22 "	Single	6.50	22 "	"	8.50	40 "	Double	11.10	40 "	"
4.50	40 "	Double	6.50	40 "	Double	9.00	40 "	"	11.15	22 "	Single
4.50	22 "	Single	7.00	40 "	"	9.10	40 "	"	11.20	40 "	Double
5.00	40 "	Double	7.10	40 "	"	9.10	40 "	"	11.30	40 "	"
5.10	22 "	Single	7.10	40 "	"	9.15	22 "	Single	11.30	22 "	
5.10	40 "	Double	7.10	22 "	Single	9.20	40 "	Double	Extra		Single
5.10	40 "	"	7.15	22 "	"	9.30	40 "	"	4.40	22 "	"
5.15	22 "	Single	7.20	40 "	Double	9.30	22 "	Single	5.00	22 "	"
5.20	40 "	Double	7.30	40 "	"	9.40	40 "	Double	5.20	22 "	"
5.30	40 "	"	7.30	40 "	"	9.45	22 "	Single	5.40	22 "	"
5.30	22 "	Single	7.40	40 "	"	9.50	40 "	Double	6.00	22 "	"
5.40	40 "	Double	7.45	22 "	Single	9.50	22 "	Single			

137 Large cars run daily.
76 Small " " "

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TABLE VIII.

Electric Car Schedule.

FURNISHED BY THE CUMBERLAND COUNTY POWER & LIGHT COMPANY.

Cars Leaving Knightville for Portland, Via Portland Bridge, From 5.55 A. M. Until 11.15 P. M.

A. M.	Capacity	Truck	A. M.	Capacity	Truck	A. M.	Capacity	Truck	P. M.	Capacity	Truck
5.55	40 Pass.	Double	8.00	22 Pass.	Single	10.30	22 Pass.	Single	12.45	40 Pass.	Double
5.55	40 "	"	8.05	40 "	Double	10.35	40 "	Double	12.55	40 "	"
6.00	22 "	Single	8.15	40 "	"	10.35	22 "	Single	12.55	40 "	"
6.05	40 "	Double	8.15	40 "	"	10.45	40 "	Double	12.55	22 "	Single
6.15	40 "	"	8.25	40 "	"	10.55	40 "	"	1.00	22 "	"
6.15	40 "	"	8.30	22 "	Single	10.55	40 "	"	1.05	40 "	Double
6.25	40 "	"	8.35	22 "	"	10.55	22 "	Single	1.15	40 "	"
6.30	22 "	Single	8.35	40 "	Double	11.00	22 "	"	1.15	40 "	"
6.30	22 "	"	8.45	40 "	"	11.05	40 "	Double	1.25	40 "	"
6.35	22 "	"	8.55	40 "	"	11.15	40 "	"	1.30	22 "	Single
6.35	40 "	Double	8.55	40 "	"	11.15	40 "	"	1.35	40 "	Double
6.45	40 "	"	9.00	22 "	Single	11.25	40 "	"	1.35	22 "	Single
6.45	22 "	Single	9.05	40 "	Double	11.30	22 "	Single	1.45	40 "	Double
6.55	40 "	Double	9.15	40 "	"	11.35	22 "	"	1.55	40 "	"
6.55	40 "	Double	9.15	40 "	"	11.35	40 "	Double	1.55	40 "	"
7.00	22 "	Single	9.25	40 "	"	11.45	40 "	"	1.55	22 "	Single
7.05	40 "	Double	9.30	22 "	Single	11.55	40 "	"	2.00	22 "	Single
7.15	40 "	"	9.35	22 "	"	11.55	22 "	Single	2.05	40 "	Double
7.15	40 "	"	9.35	40 "	Double	11.55	22 "	"	2.15	40 "	"
7.25	40 "	"	9.45	40 "	"	P. M.			2.15	40 "	"
7.30	22 "	Single	9.55	22 "	Single	12.00	22 "	"	2.25	40 "	"
7.35	22 "	"	9.55	40 "	Double	12.05	40 "	Double	2.30	22 "	Single
7.35	40 "	Double	9.55	40 "	"	12.15	40 "	"	2.35	22 "	"
7.45	40 "	"	10.00	22 "	Single	12.15	40 "	"	2.35	40 "	Double
7.45	22 "	Single	10.05	40 "	Double	12.25	40 "	"	2.45	40 "	"
7.45	22 "	"	10.15	40 "	"	12.30	22 "	Single	2.55	40 "	"
7.55	40 "	Double	10.15	40 "	"	12.35	22 "	"	2.55	40 "	"
7.55	40 "	"	10.25	40 "	"	12.35	40 "	Double	2.55	22 "	Single

TABLE VIII.

ELECTRIC CAR SCHEDULE.

P. M.	Capacity	Truck	P. M.	Capacity	Truck	P. M.	Capacity	Truck	P. M.	Capacity	Truck
3.00	22 Pass	Single	5.15	40 Pass	Double	7.25	40 Pass	Double	9.35	22 Pass	Single
3.05	40 "	Double	5.15	40 "	"	7.30	22 "	Single	9.45	40 "	Double
3.15	40 "	"	5.25	40 "	"	7.35	40 "	Double	9.55	40 "	"
3.15	40 "	"	5.30	22 "	Single	7.35	22 "	Single	9.55	40 "	"
3.25	40 "	"	5.35	22 "	"	7.45	40 "	Double	10.00	22 "	Single
3.30	22 "	Single	5.35	40 "	Double	7.55	40 "	"	10.05	40 "	Double
3.35	22 "	"	5.45	40 "	"	7.55	40 "	"	10.15	40 "	"
3.35	40 "	Double	5.55	40 "	"	7.55	22 "	Single	10.15	22 "	Single
3.45	40 "	"	5.55	40 "	"	8.00	22 "	"	10.25	40 "	Double
3.55	40 "	"	5.55	22 "	Single	8.05	40 "	Double	10.30	22 "	Single
3.55	40 "	"	6.00	22 "	"	8.15	40 "	"	10.35	40 "	Double
3.55	22 "	Single	6.05	40 "	Double	8.15	40 "	"	10.35	22 "	Single
4.00	22 "	"	6.15	40 "	"	8.25	40 "	"	10.45	40 "	Double
4.05	40 "	Double	6.15	40 "	"	8.30	22 "	Single	10.55	40 "	"
4.15	40 "	"	6.25	40 "	"	8.35	22 "	"	10.55	40 "	"
4.15	40 "	"	6.30	22 "	Single	8.35	40 "	Double	11.00	22 "	Single
4.25	40 "	"	6.35	22 "	"	8.45	40 "	"	11.05	40 "	Double
4.30	22 "	Single	6.35	40 "	Double	8.55	40 "	"	11.15	40 "	"
4.35	40 "	Double	6.45	40 "	"	8.55	40 "	"	11.15	22 "	Single
4.35	22 "	Single	6.55	40 "	"	9.00	22 "	Single	Extra		
4.45	40 "	Double	6.55	40 "	"	9.05	40 "	Double	4.25	22 "	"
4.55	22 "	Single	6.55	22 "	Single	9.15	40 "	"	4.45	22 "	"
4.55	40 "	Double	7.00	22 "	"	9.15	22 "	Single	5.05	22 "	"
4.55	40 "	"	7.05	40 "	Double	9.25	40 "	Double	5.25	22 "	"
5.00	22 "	Single	7.15	40 "	"	9.30	22 "	Single	5.45	22 "	"
5.05	40 "	Double	7.15	40 "	"	9.35	40 "	Double			

137 Double Truck Cars run daily
76 Single " " "

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APPENDIX I.

DIVISION I. PORTLAND APPROACH.

Item	Material	Quality	Unit cost	Totals	
1.	Earthwork				
1.1	Excavation	34,800 cu. yds.	$ 45	$15,660 00	
1.2	Filling	11,000 cu. yds.	30	3,300 00	
1.3	Sodding	1,500 sq. yds.	30	450 00	$19,410 00
2.	Concrete				
2.1	York Street Retaining Wall	1,300 cu. yds.	5 60	7,280 00	
2.2	New Street Retaining Wall	2,100 cu. yds.	5 20	10,920 00	
2.3	Abutment	300 cu. yds.	5 20	1,560 00	19.760 00
3.	Forms				
3.1	Labor	71,000 sq. ft.	06	4,260 00	
3.2	Lumber	150 M' B. M.	27 00	4,050 00	8,310 00
4.	Concrete Railing	1,300 Lin. ft.	1 70	2,210 00	2,210 00
5.	Street Paving				
5.1	Concrete 6-inch Slab	7,650 sq. yds.	1 00	7,650 00	
5.2	Stone Block	2,000 sq. yds.	2 00	4,000 00	11,650 00
6.1	Concrete Walks	3,000 sq. yds.	80	2,400 00	
6.2	Walk Curbing	3,300 lin. ft.	60	1,980 00	4,380 00
7.	Reinforcing Steel	86 tons	50 00	4,300 00	4,300 00
8.	Finishing	7,400 sq. ft.	02	148 00	148 00
9.	Waterproofing	29,000 sq. ft.	04	1,160 00	1,160 00
10.	Lamps	22	30 00	660 00	660 00
					$71,988 00
11.	Contingencies, 5%				3,599 40
					$75,587 40
12.	Contractor's Profit, 10%				7,558 74
					$83.146 14
13.	Engineering, 5%				4,157 31
					$87.303 45
14.	Real Estate Estimated				77,700 00
	Total				$165,000 00

NOTE—See text of report for discussion of estimates before attempting to compare the figures given herein with other unit costs.

DIVISION II. COMMERCIAL STREET VIADUCT.

Item	Material	Quantity	Unit Cost	Totals	
1.	Piers 1 to 8 to Arch Spring....				
1.1	Piles..........................	950–50 ft.	$13 50	$12,825 00	
1.2	Sheeting, 4-inch Y. P.	144,000 ft. BM.	60 00	8,640 00	
1.3	Excavation	5,300 cu. yd.	2 00	10,600 00	
1.4	Concrete	5,040 "	5 00	25,200 00	
1.5	Form Labor.....................	32,000 sq. ft.	06	1,920 00	
1.6	" Lumber................	60,000 ft. BM.	28 00	1.680 00	$60,865 0
2.	Pier 9 to Arch Spring				
2.1	Dredging.......................	1,700 yds.	30	510 00	
2.2	Piles..........................	286-30 ft.	8 10	2,377 00	
2.3	Excavation under air.........	120 yds.	5 00	600 00	
2.4	Caisson Concrete.............	1,680 yds.	5 60	9,408 00	
2.5	" Reinforcement........	70,000 +	02¼	1.575 00	
2.6	" Air lock..............	2	60 00	120 00	
2.7	" Pile capping..........	400 yds.	8 00	3.200 00	
2.8	" Filling...............	870 "	80	696 00	
2.9	" Stone Facing	3,400 cu. ft.	1 10	3,740 00	
2.10	Concrete to Arch Spring......	300 yds.	4 90	1,470 00	
2.11	Form Labor..................	24,000 sq. ft.	08	1,920 00	
2.12	" Lumber...............	50,000 ft. BM.	28 00	1,400 00	
2.13	Timber Diaphragm	31,000 ft. Sp.	42 00	1.302 00	28, 318 0
3.	Arch Rings, to Pier 10.........				
3.1	Concrete	3,800 yds.	5 60	21,280 00	
3.2	Reinforcing, Structural.......	250,000 +	04	10,000 00	
3.3	Form Labor..................	57,000 sq. ft.	10	5,700 00	
3.4	" Lumber................	114,000 ft. BM.	28 00	3.192 00	
3.5	Skewbacks, C. I..............	140 tons	70 00	9,800 00	49.972 00
4.1	Concrete Piers and Beams....	1,700 yds.	6 50	11,050 00	
4.2	" Floor and Walk....	965 "	5 60	5,404 00	
4.3	Form Labor..................	90,500 sq, ft.	10	9,050 00	
4.4	" Lumber................	180,000 ft. BM.	28 00	5.040 00	
4.5	Reinforcing	353,000 +	02½	8,825 00	39,369 00
5.	Concrete Railing..............	2,000 Lin. ft,	1 70		3.400 00
6.	Wood Paving and Cushion....	5,100 sq. yds.	1 75		8,925 00
7.	Finishing.....................	4,500 sq. ft.	02		90 00
8.	Waterproofing	46.000 "	04		1,840 00
9.	Lamps........................	38	30 00		1,140 00
10.	Stairway, Commercial Street.				
10.1	Concrete	70 yds.	8 00	560 00	
10.2	Reinforcement................	10,000 +	03	300 00	
10.3	Form Labor..................	3,000 sq. ft.	12	360 00	
10.4	" Lumber................	10,000 ft. BM.	28 00	280 00	
10.5	Railing.......................	160 lin. ft.	2 00	320 00	
10.6	Mason Treads................	61	2 00	122 00	1,942 00
					$195,861 00
11.	Contingencies, 5%				9,793 00
					$205.654 00
12.	Contractor's Profit, 10%.......				20,565 00
					$226,219 00
13.	Engineering, 5%.............				11,311 00
	Total......................				$237,530 00

Total length 1,000 ft. Cost per lin. ft. $237 53
Width 62 ft. " " sq. ft. 3 84

NOTE:—See text of report for discussion of estimates before attempting to compare the figures given herein with other unit costs.

DIVISION III. BASCULE SPAN.

Item	Material	Quantity	Unit Cost	Totals	
1.	Piers 10 and 11				
1.1	Dredging....................	3,230 yds.	$ 30	$ 969 00	
1.2	Piles........................	1,950-30 ft.	8 10	15,795 00	
1.3	Excavation under air.......	1,100 c.y.	5 00	5,500 00	
1.4	Caisson Concrete...........	6,718 "	5 60	37,620 00	
1.5	" Reinforcement.....	157 tons	45 00	7,065 00	
1.6	" Air lock	4	75 00	300 00	
1.7	" Pile capping........	3,500 yd.	8 00	28,000 00	
1.8	" Filling.............	8,300 "	80	6,640 00	
1.9	" Stone Facing.......	12,000 c.f.	1 10	13,200 00	
1.10	Concrete to Floor Level.....	5,540 yds.	4 90	27,146 00	
1.11	Form Labor................	155,000 s.f.	06	9,300 00	
1.12	" Lumber..............	310,000 ft. BM.	28 00	8,680 00	
1.13	Timber Diaphragm.........	164,000 "	42 00	6,888 00	$167,103 00
2.	Towers....				
2.1	Concrete....................	367 c.y.	5 60	2,055 00	
2.2	Cut Stone	5,040 c.f.	3 00	15,120 00	
2.3	Form Labor..	7,950 s.f.	08	636 00	
2.4	" Lumber..............	16,000 ft. BM.	28 00	448 00	
2.5	Windows...................	1,032 s.f.	40	413 00	
2.6	Doors.......................	250 "	35	88 00	
2.7	Roof Tile....................	900 "	20 00	180 00	
2.8	Stairways	4	50 00	200 00	
2.9	Plumbing			100 00	
2.10	Heating.....................			75 00	
2.11	Finish Floors...............	2,300 s.f.	06	138 00	
2.12	Office Equipment..........			100 00	
2.13	Reinforcing Steel....... ...	24 tons	45 00	1,080 00	
2.14	Concrete Railing & Benches, etc...	110 ft.	3 00	330 00	
2.15	Finishing...................	3,000 s.f.	02	60	21,023 00
3.	Steel Bascule...............				
3.1	Structural Steel............	273 tons	100 00	27,300 00	
3.2	Railing..........	4½ "	100 00	450 00	
3.3	Plank Floor & Walk........	48,000' Spr.	40 00	1,920 00	
3.4	Painting Steelwork.........	278 tons	2 00	556 00	30,226 00
4.	Mechanical Equipment.....				
4.1	Racks.......................	40 "	70 00	2,800 00	
4.2	Counterweight.............	800 yds.	10 00	8,000 00	
4.3	Shafting, Journals & Gears	65 tons	400 00	26,000 00	
4.4	Motors, Controllers & Wiring	4-40 H.P. 4-3 H.P. 172 H.P.	20 00	3,440 00	
4.5	Signal System..............			300 00	
4.6	Engine Generator Set.......			2,500 00	
4.7	Storage Battery............			2,500 00	
4.9	Oil Buffers			6,000 00	
4.10	Gates & Locking Mechanism			3,000 00	54,540 00
5.	Lamps......................	8	30 00	240 00	240 00
6.	Fenders & Dolphins.........				
6.1	Piles........................	250	15 00	3,750 00	
6.2	Timber......................	35,000 ft.B.M.	60 00	2,100 00	5,850 00
					278,982 00
7.	Contingencies, 5%..........				13,949 00
					$292,931 00
8.	Contractor's Profit, 10%.....				29,293 00
					$322,224 00
9.	Engineering, 5%...........				16,111 00
	Total....................				$338,335 00

Total length 270-ft., Cost per lin. ft., $1,250.00
" width 62-ft., " " sq. ft., 20.20

NOTE:—See text of report for discussion of estimates before attempting to compare the figures given herein with other unit costs.

DIVISION VI. HARBOR SPANS.

Item	Material	Quantity	Unit cost	Totals	
1	Piers 12-13-14 to Arch Spring same as Pier No. 9	3	$29,000 00	$87,000 00	$87,000 00
2.	Pier 15 to Arch Spring				
2.1	Excavation	130 cu. yds.	2 00	260 00	
2.2	Piles	155–50 ft.	13 50	2,092 50	
2.3	Concrete	750 cu. yds.	5 10	3,825 00	
2.4	Mud Filling	180 "	80	144 00	
2.5	Stone Facing..............	3,000 cu. ft.	1 10	3,300 00	
2.6	Form Labor...............	6,800 sq. ft.	08	544 00	
2.7	" Lumber.......	14 M' B. M.	28 00	392 00	10,557 50
3.	Superstructure............				
3.1	Piers, Concrete............	90 cu. yds.	5 60	504 00	
3.2	Steel Work, Structural....	1700000 +	04	68,000 00	
3.3	Concrete Frame...........	340 cu. yds.	6 20	2,108 00	
3.4	Plaster on Steelwork	80,000 sq. ft.	10	8,000 00	
3.5	Hinges	30,000 +	04	1,200 00	
3.6	Form Labor...............	73,500 sq. ft.	08	5,880 00	
3.7	Form Lumber	140 M' B. M	28 00	3,920 00	
3.8	Concrete Floor and Walk.	620 cu. yds.	5 60	3,472 00	
3.9	Reinforcing Steel	47 tons	44 00	2,068 00	95,152 00
4.	Steel Railing..............	32,000 +	04	1,280 00	1,280 00
5.	Wood Paving and Cushion	4,140 sq. yds.	1 75	7,245 00	7,245 00
6.	Finishing	5,000 sq. ft.	02	100 00	100 00
7.	Painting Railing..........			75 00	75 00
8.	Waterproofing	48,000 sq. ft.	04	1,920 00	1,920 00
9.	Lamps				
9.1	Cluster Lamps	8	30 00	240 00	
9.2	Single "	20	20 00	400 00	640 00
					$203,969 50
10.	Contingencies, 5%				10,198 47
					$214,167 97
11.	Contractor's Profit, 10%...				21,416 79
					$235,584 76
11.	Engineering, 5%..........				11,779 24
	Total				$247,364 00

Total length 800 ft. Cost per lin. ft. $309.20
" width 62 ft. " " sq. ft. 4.98

NOTE.—See text of report for discussion of estimates before attempting to compare the figures given herein with other unit costs.

DIVISION V. SOUTH PORTLAND APPROACH AND ABUTMENT.

Item	Material	Quantity	Unit Cost	Totals	
1.	Abutment...........				
1.1	Excavation	530 cu. yds.	$2 00	$1,060 00	
1.2	Piles	180–50 ft.	13 50	2,430 00	
1.3	Concrete	1,240 cu. yds.	5 60	6,944 00	
1.4	Stone Facing...............	3,720 cu. ft.	1 10	4,092 00	
1.5	Form Labor.................	23,072 sq. ft.	06	1,384 00	
1.6	Form Lumber...............	46,150 bd. ft.	27 00	1,246 00	
1.7	Reinforcing...	22 tons	45 00	990 00	$18,146 00
2.	Earth Fill...................	112,200 cu. yds.	50	56,100 00	56,100 00
3.	Rip Rap	1,666 sq. yds.	1 25	2,082 00	2,082 00
4.	Concrete Paving...........	4,000 "	1 00	4,000 00	4,000 00
5.1	Sidewalk	1,400 "	80	1,120 00	1,120 00
5.2	Sidewalk Curbing (2 sides)	3,120 lin. ft.	60	1,872 00	1,872 00
6.	Concrete Railing...........	1,440 "	1 70	2,448 00	2,448 00
7.	Lamps	18	30 00	540 00	540 00
					$86,308 00
.	Contingencies. 5%...........				4,315 00
					$90,623 00
9.	Contractor's Profit, 10%.....				9,062 00
					$99,685 00
10.	Engineering. 5%				4,984 00
					$104,669 00
11.	Real Estate 20,000+50%				30,000 00
				Total,	$134,669 00

Total length 780 ft., Cost per lin. ft. $173.00
Total width 70 " " " sq. " 2.47

NOTE—See text of report for discussion of estimates before attempting to compare the figures given herein with other unit costs.

RECAPITULATION.

Item		Totals	
1.	Portland Approach	$87,300 00	
2.	Commercial Street Viaduct	237,530 00	
3.	Draw Span and Piers	338,335 00	
4.	Harbor Spans	247,364 00	
5.	South Portland Approach	104,669 00	$1,015,198 00
	Real Estate:		
	Portland Approach	77,700 00	
	South Portland Approach	30,000 00	107,700 00
	Test Borings	10.000 00	10,000 00
			1,132,898 00
	Interest on Investment During Construction Period at 4%		45,316 00
	Grand Total		$1,178,214 00

Total length 3,111 ft. Cost per lin. ft., $379.00
" width 62 ft. " " sq. ft., 6.12

APPENDIX II.

GENERAL STATISTICS.

PROPOSED BRIDGE.

Commercial Street Viaduct	1,000 feet	
Draw Span	266 feet	
Harbor Spans	800 feet	
Total Bridge		2,066 feet
South Portland Approach (Fill)	1,045 feet	
Portland Approach, East to State Street	710 feet	
Portland Approach, West to Commercial Street	700 feet	
Total Approaches		2,455 feet
Total length of construction work over all		4,521 feet
Total length, South Portland end to West Commercial Street		3,800 feet
Total length, South Portland end to Park Street		4,200 feet
Width of roadway	46 feet	
Total width of Bridge	62 feet	
Channel:		
Clear width	170 feet	
Depth of water at M. L. Tide	40 feet	
Clear Head Room at M. L. Tide	50 feet	
Quantities of Materials:		
Earthwork	185,000 cubic yards	
Concrete	50,000 cubic yards	
Crushed Rock	45,000 cubic yards	
Sand	23,000 cubic yards	
Cement	90,000 barrels	
Steel, Reinforcing	550 tons	
Steel, Structural	1,375 tons	
Piles	4,550	
Total weight of bridge between abutments	159,200,000 lbs.	

PRESENT BRIDGE.

South End Trestle	495 feet	
Draw Span	190 feet	
North End Trestle	270 feet	
Total Bridge		955 feet

South Portland Approach (Fill)		1,000 feet
Portland Approach from Commercial Street Via Railroad Wharf		1,300 feet
Total length, South Portland to Commercial Street		3,255 feet
Total length, South Portland to York and Park Streets		3,900 feet
Width of Drawbridge Roadway	19 feet	
Total width of Drawbridge	26 feet	

Channel:

Clear width	140 feet
Depth of Water at M. L. Tide	35 feet
Clear Head Room at M. L. Tide	16 feet

VAUGHNS BRIDGE.

Lengths:

Portland Approach		250 feet
Truss Spans (6 @ 91)	546 feet	
(2 @ 91-6)	183 feet	
		729 feet
Swing Draw		235 feet
South Portland Approach		100 feet
		1,314 feet

Widths:

Roadway	39 feet clear
Bridge over all	55 feet
Walks (2 @ 7-feet wide)	14 feet

Heights:

Draw Roadway 16.83 above M. L. Tide.
Down Grades each way.

Channel:

120-feet clear width x 14-feet deep at M. L. Tide.

Total cost about	$500,000 00
Total length 1,314-ft., Cost per lineal foot	380 00
Total width 55-feet, Cost per square foot	6 90

DIVISION STREET BASCULE BRIDGE—CHICAGO, ILL.

Length, center to center of trunnions	172 ft. 8 inches
Width, about	60 feet
Foundation	40 feet high

Cost:

Superstructure	$160,000 00	
Substructure	94,000 00	
Total		$254,000 00