

PROCEEDINGS
OF
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK

Edited by
THE PUBLICATION AND LIBRARY COMMITTEE

W. H. ROBERTS, Editor and Business Manager

1904

NEW YORK
Published by the Society

1905

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THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK

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**THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.**

Paper No. 7.

**INVESTIGATIONS FOR THE NEW WATER
SUPPLY OF THE CITY OF NEW YORK.**

BY PROFESSOR WILLIAM H. BURR, MEMBER OF THE SOCIETY.

PRESENTED FEBRUARY 24, 1904.

Mr. President and Gentlemen of the Municipal Society:

Your President has spoken favorably of the work of the Commission on Additional Water Supply for this city. I shall not attempt to give any extended or detailed account of that work, but I shall try to cover some of its main features with the aid of a few slides, for which you are indebted to another member of the Commission, and not to me. I wish to make that explanation because it is through the courtesy of Mr. Hering that we have at our disposal even the few slides to be shown.

This Commission, with which I suppose all members are familiar, was created a year ago last December for the purpose, chiefly, of ascertaining sources from which an additional supply of water for the City of New York can be most readily obtained. There were certain other and incidental features of the work which were of almost equal importance to the city, such as the consideration and study of the waste of water, of which we have all heard a great deal, but which, after all, does not amount to so much as we might suppose; ascertaining where a temporary supply of water could be obtained, if possible, and the prospective growth of the city bearing upon the amount of water which would be required in the future. It will be best this evening, however, to confine our attention almost entirely to the main subject, which is the investigation of additional sources of supply.

At the present time the population of Greater New York is not much under 3 750 000 people, and the rate of consumption about 120 gal. per head of population per day. The amount of water drawn daily from the watershed of the Croton River, about 360 square miles in area, and from the additional 20 square miles of The Bronx and Byram sheds, was a little under 290 000 000 gal., at the end of our work in November. It is correct to say that the average draft per day is about 290 000 000 gal. from those sources. Approximately speaking, the amount of water consumed by the remainder of the city is perhaps another 110 000 000, making in round numbers about 400 000 000 gal. per day. The remaining supply, as you are aware, is taken chiefly from the ground-water and surface-waters of Long Island and a small quantity from Staten Island. It is possible to develop to a small extent further the supply from the Croton watershed by additional storage, but the limit of that supply is practically reached for the average year. It is not reached for such a season as that we have just passed through in which the rainfall has been phenomenally large, but it is much more than reached for low rainfall seasons, such as we frequently experience. It is not exaggerating to state that a low-water season at any time, or, worse yet, two consecutive low-water seasons, such as we have had a number of times in the past, would produce great distress and be a source of grave danger. It is therefore in the highest degree urgent that the City of New York take immediate measures to increase its water supply.

It has been stated, and stated in all sincerity and with force, that if the waste of the city water could be curtailed that there would be sufficient water saved to obviate any increase in its water supply for many years. I shall not attempt to controvert that statement in detail, but I believe that no one can study the present situation of New York City's water supply without being convinced that such a policy would incur the gravest danger to the city. Careful investigations have shown that the waste of water is not large. In fact, the most that can be shown at present is that the waste amounts to about 15% only of the present supply. It may be somewhat more than that, and there may be sources of waste which have escaped investigation, but it is difficult, if not impossible, to find a source

of material error. Again, it is extremely difficult to reduce that waste to any sensible extent. Judging from actual experience in this and other cities, if everything were favorable for the reduction of waste, it would scarcely be possible to produce a saving of 10% after two years of the most earnest efforts. A large proportion of the people of the city desire to use water in a way which perhaps may be considered extravagant; but they are willing to pay for it. They want water and they will have it if it comes through the distribution system. It is only reasonable to state that in view of the consumption in large cities throughout the country, even 120 gal. per day per head of population is not so large as one might suppose. At this point we shall be confronted at once with figures from European cities with the statement that eminent engineers on the other side of the water have said that any use of over 60 gal. of water per head per day, or 50, or perhaps even 40, is senseless waste. Those gentlemen are not familiar with the conditions in this country. The practice of using public water here is far more general and elaborate than in Europe. It is a matter of experience, I believe, in every city of the country that as people become accustomed to the use of water they demand more of it. It cannot be known how much longer this condition of things may be maintained, but it certainly exists at the present time. If every building in the city were metered and if every reasonable measure for the reduction of waste were enforced, I doubt whether 20 years hence the consumption of water in this city per head of population per day would be much under 150 gal. It may be said that it ought not to be so, and I assent, but the question is whether it will be so, not whether it ought to be. If conclusions are to be drawn from past experiences, I think it must be admitted that we must look for a future daily consumption per head of population in this city greater than exists to-day.

These conditions confronted the Commission on Additional Water Supply at the beginning of its work. It may be a matter of doubt what the population of the City of New York will be 25 years hence, but using existing data and taking the increasing population as it has developed within the last 20 years, we can reach no other conclusion than that between 1925 and 1930 the popula-

tion of Greater New York will be at least double its present amount, or, in round numbers, 7 000 000 people.

In view of the instructions given to the Commission, it seemed necessary that a broad view of the question should be taken and that the problem of the future water supply of the city should, as far as possible, be settled for a long period in the future. At the same time these instructions were such that the Commission was not permitted to consider any source of supply of an interstate character, for the reason that any attempt to take water flowing from this State into other States would be followed by litigation of so serious a character that the construction of an additional supply would be deferred indefinitely; in other words, the Commission was limited to the consideration of those sources which were available without the shadow of litigation over them. Those instructions shut out such streams as the Housatonic, the Ten Mile River, which is a branch of the Housatonic, or any stream flowing from New York into New Jersey. The investigations of the Commission were thus practically limited to the waters of the Hudson River or to those tributary to it.

The first impressions of the Commission were favorable to taking the water from the Hudson River at a point between Poughkeepsie and Hyde Park, pumping it to a proper elevation on the high ground east of the river, and bringing it from that point into the city. That source possessed the attraction of practically an unlimited supply. It is confidently believed that filtration would so purify the water of the Hudson River as to make it of excellent quality for the purposes of the city. It also became an important matter to determine whether the additional water supply should be brought into the city at a low level, like that of the present Croton water, or whether it should be a high level supply. The rapid increase of population in the Bronx, much of it in a territory of high elevation, is a material element in this question. A high pressure would add much to the efficiency of the fire service of the new supply. It was therefore concluded, after a thorough investigation of the whole subject, that the additional supply should be a high service supply with the water surface in a distributing reservoir to be built at the northern end of the city on high ground at an elevation of 295-ft.

above tide. It would be perfectly feasible to raise the water of the Hudson River by pumping to any desired elevation and to locate filters suitable for such a place within a reasonable distance of the river. Further investigations, however, developed the fact that gravity sources of supply are available, and the work of the Commission was finally centered upon the development of them. As a matter of fact, the estimates of cost showed that there was not much difference between the expense per 1 000 000 gal. of pumping water from the Hudson or bringing it from the gravity sources, but the gravity system has other marked advantages. It is simpler, its maintenance and operation require less skillful attendance, and it is more nearly self-maintaining. Hence, without going into details which were considered at great length by the Commission, it finally decided to adopt for its purpose the gravity plan.

The nearest watershed available north of the Croton is that of Fishkill Creek, which lies adjacent to it; and in that water-shed there is ground sufficiently high, at Stormville, to locate a filter plant large enough to filter all the gravity water of the additional supply from whatever source.

By considering the increase of population which would take place within the next 20 or 25 years and using 150 gal. per head of population per day for the purpose of estimate, but not committing the Commission necessarily to that consumption, it was found that about 500 000 000 gal. per day would be required at the end of that period, in addition to the present supply for that part of the city included in the Boroughs of Manhattan and The Bronx. It was necessary, therefore, to secure sufficient drainage area to supply that water when and as it should be needed.

In connection with the Stormville filter site, which proved to be an excellent one for the purpose of filtering all the new water, I should state that the Commission was unanimous in the judgment that provision should be made for filtering not only all the water of the additional supply, but that the entire Croton supply should also be filtered at the earliest practicable date.

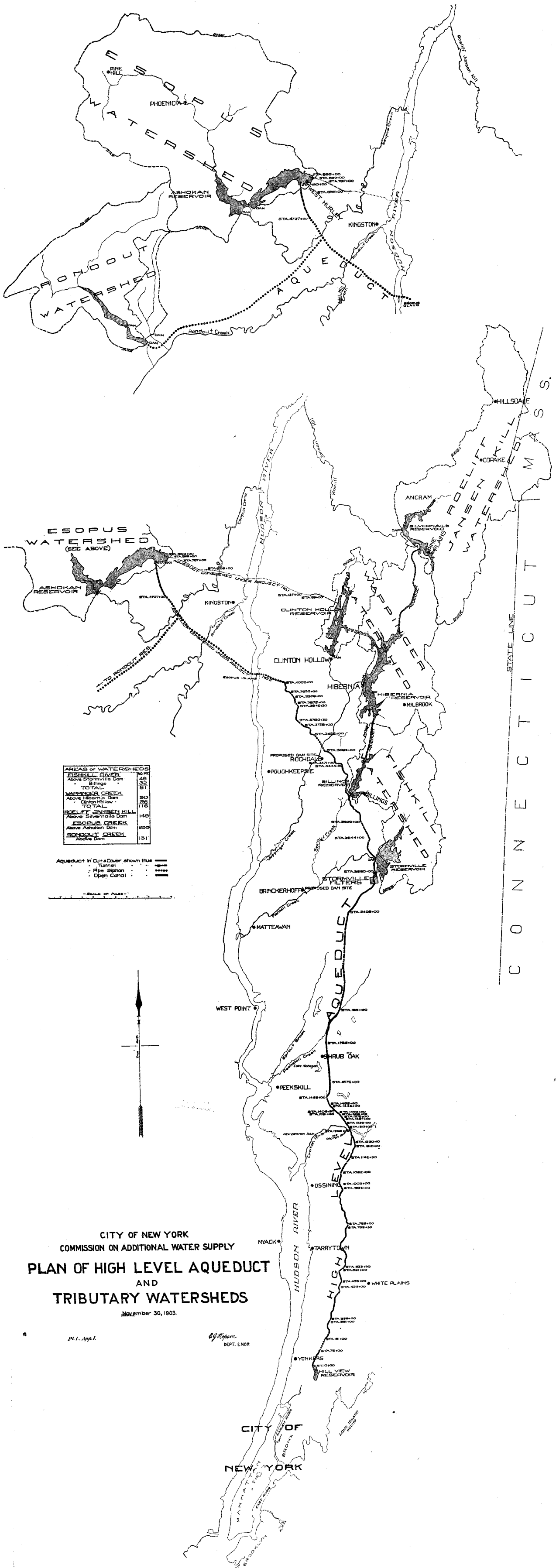
This skeleton sketch of the water supply condition brings us to the point in the Commission's work where it was necessary to ascer-

tain the specific sources to yield the quantity desired. The general map shows, not only those watersheds which are available under the instructions of the Commission, but also others which have been discussed at one time or another in connection with an additional water supply for the city. The portion lying partly in the State of Massachusetts and partly in the State of Connecticut is the available part of the Housatonic shed, the water from which could be obtained most economically were it not for its interstate character.

The same observation can be made in reference to the Walkill shed, part of which lies in New Jersey and part in the State of New York. The remainder of the indicated portions is watershed available under the instructions to the Commission for the additional supply of the city. Those portions on the west side of the Hudson River are Catskill Mountains drainage areas. The upper part is the Esopus and the lower part the Rondout, both of which are well adapted in every way for purposes of additional supply. The watershed immediately north of the Esopus is the Schoharie, which discharges its waters into Mohawk River and thence down the Hudson; but a part of it can be readily diverted by a tunnel into the Esopus watershed, so that the Esopus may include, if desired, a part of the Schoharie.

The portion seen near the top of the map is the Adirondack region, which has been frequently considered one of the desirable sources of supply for the City of New York. It is believed, however, that with the resources of filtration now available it is much more economical and judicious to allow the Adirondack water to flow down the Hudson to the vicinity of Hyde Park, pump it to a suitable elevation, filter it and let it flow thence by conduit into the city.

The first reservoir north of the Croton basin would be at Stormville, near the filter site. It lies on Fishkill Creek, and the combined watershed of it and of the Billings Reservoir, which is on Sprout Creek, a tributary of the Fishkill, has an area of 81 sq. miles. The elevation of the water surface in the Stormville Reservoir and in the Stormville filters is about 364 ft. above tide. The elevation of the water in the Billings Reservoir, which is also in the



Fishkill watershed, is about 383 ft. above tide. The available capacity of the Stormville Reservoir is about 10 000 million and of the Billings Reservoir about 6 800 million gallons.

The Wappinger Creek watershed lies immediately north of the Fishkill and it contains two or three good reservoir sites. That one which would be available for a high service supply is near the point called Hibernia, and the reservoir would have an available capacity of 30 500 million gal., with a surface elevation of 373 ft. above tide. In the same watershed, three or four miles from Hibernia, is a site for a reservoir, which is called the Clinton Reservoir, having a capacity of about 13 900 million gal. and an elevation of 387 ft. above tide. That is a very small shed, however, of not more than about 22 sq. miles, too small to be developed except as an incident of a more extended system. That reservoir would not, in the ordinary course of events, be built in connection with the Hibernia Reservoir unless it should be found desirable to bring the water from the Jansen Kill watershed into that of the Wappinger through the locality of Clinton.

The area tributary to the Hibernia Reservoir is perhaps 90 sq. miles. On the north of the Wappinger shed there is located the drainage area of the Jansen Kill, a creek which runs northwesterly from the point called Silvernails and enters into the Hudson. A small portion of this watershed lies in the State of Massachusetts, but it is in a mountainous district and so small a portion of the total area that the interstate question could scarcely arise. At Silvernails there is an excellent dam site where a reservoir could be built with a capacity of 17 200 million gal. and with an elevation of surface of 465 ft. above tide. In our plans and estimates we assumed that the water from the Silvernails Reservoir would be brought largely in open canal down into the Hibernia Reservoir, thence down to the Billings Reservoir and to the Stormville filter site, making a continuous chain of reservoirs from the Jansen Kill down into the Fishkill. Unfortunately, there is much limestone in those watersheds, and the water of the Jansen Kill particularly is harder than desirable, but not hard enough to exclude it from consideration. The waters of the Fishkill and of the Wappinger must also be classed as hard, although they are entirely avail-

able. The best water, however, to be found anywhere under the instructions given to the Commission is that from the westerly side of the river in the Catskill Mountain regions. There are two such streams, one of which is Esopus Creek, flowing down from the southeasterly slope of the Catskill into the Hudson, a few miles north of Kingston. The area of the Esopus watershed is about 255 sq. miles. Rondout Creek, immediately south of the Esopus, has a smaller watershed, about 160 sq. miles, well located for development for additional supply, but which the Commission did not have time to examine completely. The water of Esopus Creek is remarkably pure and soft. There is no limestone in its watershed above Bishop's Falls, where the reservoir dam would be located. The dam site at Bishop's Falls is a good one, and the reservoir which would be formed by it is larger than any reservoir hitherto constructed for municipal purposes. The available capacity would be about 67 000 million gal. It is almost an ideal reservoir. Water would be taken from the reservoir through an aqueduct crossing the river at some point not precisely determined, but just below Hyde Park; thence to the vicinity of the Billings Reservoir, but not mingling with the Billings Reservoir water, to the Stormville filter site. The Esopus water would be brought to that point in an independent aqueduct or conduit. The waters from the sheds north of the Fishkill would be brought to the Stormville filter site in an independent aqueduct also, thus avoiding mingling the two waters until the filter site is reached. At that point it would be feasible to make any desired combination of those waters. The hard waters on the easterly side of the Hudson would be mingled with the pure and soft waters from the westerly side, so as to reduce the hardness when delivered into the distribution system of the city, at least as low as that of the Croton.

The Rondout shed was not carefully surveyed, but it was reconnoitered. The Esopus watershed was carefully surveyed. The preliminary investigations in the Rondout shed were carried far enough to establish the fact that it is available for use and that reservoirs may be constructed at suitable places and that an aqueduct may also be built to connect with the aqueduct from the Ashokan Reservoir, on the Esopus. As those two waters are practically

of the same character, there is no reason to avoid mingling them. These aggregate watersheds, which have been outlined in this imperfect manner, will give us more than the 500 000 000 gal. daily required.

It was the recommendation of the Commission that a 500 000 000-gal. aqueduct should be constructed from the high-service Hill View Reservoir, at the northern limits of the city, to the Stormville filters. From that point a 400 000 000-gal. aqueduct should be carried over into the Esopus watershed, with which the aqueduct from the Rondout Creek would connect at a proper point westerly of the Hudson. A 300 000 000-gal. aqueduct would then be constructed from the Stormville filters to the Billings Reservoir and carried up to the Hibernia Reservoir. A 200 000 000 to 300 000 000-gal. aqueduct could be built from the Hibernia up to the Silvernails Reservoir, which would be almost entirely an open canal.

This is an imperfect outline of the plan recommended by the Commission for the 500 000 000-gal. additional water supply. General descriptions and specifications for portions of the work have been prepared. Full general specifications for the Stormville filter and careful studies for the main structures required have been made. In fact, I suppose that almost any portion of the work could be put under contract within three months' time. The portion of the high-level aqueduct from the Croton shed into the Fishkill would be a tunnel through the high mountainous region between the two drainage areas. This tunnel could be put under contract, if desired, in a very short time.

I think I am within reason in stating that the investigations of the Commission have put the question of an additional supply for the city upon so clear and definite a foundation that no serious questions of doubt can arise hereafter in connection with it. When construction is begun, or before, details must be filled in by additional surveys in the field and the details of structures must be worked out, but the main general features are available for the city at the present time.

A large part of the work of the Commission was performed along the Hudson River to determine the flow of salt water under tidal influences. Unfortunately, the water in the Hudson River

was unusually high during the entire summer. You will remember that there was a severe drought in the spring, which was followed by a remarkably wet season, which kept the water at such high stage in the river that the tidal influences in creating an upflow of salt water were much diminished, but a large force was kept at work on the river making observations from the Narrows to Albany. Sanitary examinations were also made over all the watersheds involved, even out into the Mohawk drainage area and into the Adirondacks. The report, when printed, will be found to contain a great mass of exceedingly valuable information for the city in the future.

It would not be fair to the Commission, or to the general question under discussion, not to touch, at least for a short time, upon the investigations on Long Island, but I shall do so for a few moments only.

The work consisted in a most careful and exceedingly interesting examination, partially of the surface waters of Long Island and largely of its ground-waters. There is no better water known than the naturally filtered, deep ground-water in the deep sands of such a stretch of country as that which we find on Long Island. In order to determine the availability of that water, it was necessary to make a large number of borings, which were distributed not only over Nassau County, but over a considerable portion of the island lying east of Nassau County. An underground water surface has a topography as marked as that of the surface of the earth above it, and that is strikingly true on Long Island. It was the purpose of these investigations to determine as far as possible the extent of the underground water, which involved ascertaining its varying height in the numerous borings sprinkled all over Nassau County and over a large portion of the island to the east of it, and also in observing the elevation of water in open wells. Not far from 1000 open wells were carefully located all over that part of Long Island to which I have referred, and in addition to that, nearly 400 wells were bored or sunk for the purpose of observation. These observations were carried on throughout the entire season from spring until about the first of November. The underground-water topography was determined with its hills and valleys precisely of the same

general character as, but, of course, not corresponding with, the surface of the ground above it. This water topography will cause flowing wells to exist where they are driven near the foot of a water slope, if the overlying earth is not too deep. The results of these investigations, both as to surface and underground waters, are such as to dispose conclusively of the rather reckless speculation which has been indulged in at times and under which it has been asserted that the underground water of Long Island is at least partly due to a deep subterranean flow from the Housatonic region in Connecticut and Massachusetts. The water in the deep sands of Long Island is large in volume and excellent in quality, but it comes from the rainfall on Long Island and from nowhere else. It is perhaps a hazardous speculation to estimate how much additional water can be obtained from the sands of Long Island in Nassau County or from the district east of it. It is scarcely safe to venture a guess because that is about all that it can be called, but it need not surprise one if 100 000 000 to 150 000 000 gal. a day should prove to be available from this source.

DISCUSSION.

MR. RUDOLPH HERING, Member of the Society.—I have personally felt that New York City will very likely go over to the Esopus water-shed at once and get the Catskill Mountain water and not get the hard waters of the Wappinger Creek and Roelif Jansen Kill. We all know how difficult it is to get waters from a territory taken up by manufacturing establishments and other private interests. The ground-water from Long Island, which formerly was treated as of secondary importance, should now come to the fore. It is really the best water of Long Island and should be preferred to the surface water, which is subjected to pollution and which, as Mr. Burr has stated, should be filtered before it is brought into the city. But the ground-water does not need to be artificially filtered. It is spring water naturally filtered and excellent in quality. We could not say that it is taken in the most advantageous way to-day, but ways are indicated how to take it properly, and progress is being made in that direction. In fact, some collecting galleries are being put in now on Long Island, which we think a better mode of getting the ground-water out of the ground than that used previously, and we also think still further improvements can be made.

MR. NELSON P. LEWIS, President of the Society.—I would like to ask if it was the intention of the Commission to filter the waters from Esopus and Rondout. You propose to bring them down to the Stormville filter beds, but I did not understand whether or not you intended to filter them.

PROFESSOR BURR.—It is recommended to filter the entire additional supply from whatever source.

MR. LEWIS.—I thought that these waters were of such admirable purity that you proposed to mix them as they came with the filtered waters from the east side of the Hudson.

PROFESSOR BURR.—The waters from the east and west sides of the river will be mingled, but it is the purpose to filter the mingled waters.

MR. LEWIS.—What attention has been paid to the quality of the underground water from Long Island? Several years ago there was much complaint of the odor and color of Brooklyn water, which was attributed to the presence of certain forms of algæ—the *Asterionella*, I believe—and it was stated that they develop more readily in underground waters when exposed to light and air than in surface waters?

MR. DANIEL D. JACKSON, Member of the Society.—Before the use of ground-water for the Brooklyn supply, very much less

trouble was experienced in the distributing reservoirs. The use of ground-waters has caused the microscopic growths in these reservoirs to a very large extent, and it is undoubtedly a fact that they greatly favor such growths unless the reservoirs are covered. The only means of preventing these growths has been successfully used at the Ridgewood Reservoirs.

There are at Ridgewood three large reservoirs. The water which flows into all three reservoirs is practically of the same quality, but at no time, so far, have all three been contaminated with microscopic growths; so that when one reservoir becomes contaminated it is by-passed and the water allowed to flow through the other two. If, for any reason, two of them develop micro-organisms at the same time, the water is run through the third one only. The by-passes are so constructed that the water may be allowed to stand in any one, in any two, or in all three of the reservoirs. In the latter case the water would be pumped through the by-pass, around the reservoirs and into the distributing system without having been exposed to the sunlight. Any distributing reservoir may be by-passed, but the pressure is much more easily regulated when there is more than one reservoir, or where the one reservoir is divided into sections.

The principal source of tastes and odors at Mt. Prospect Reservoir has been the diatom *Asterionella*. This star-shaped organism is essentially a ground-water growth. In moderate numbers it produces an aromatic odor which is not very different from the geranium leaf, but in large numbers it causes a very disagreeable fishy odor. At Mt. Prospect Reservoir, also, a by-pass has been constructed, and when the *Asterionella* becomes too numerous in the water this by-pass is put into service. An abundant growth of *Asterionella* requires that the water should be in constant circulation, and it usually takes from one to two weeks for the growth to disappear when the reservoir is not in use.

It is undoubtedly a fact that judicious by-passing not only serves to remedy the evil at the time, but goes a long way toward preventing future trouble by reducing the number of spores (or seeds) produced at the time of growth and stored at the bottom of the reservoir, to be developed at the next favorable opportunity. In reservoirs where the water is by-passed as soon as any odor-producing organism begins to be in evidence, it has been noted that the seasons of heavy growths are less numerous and less troublesome, and that the organisms do not rise in numbers to as high a point as they did before systems of by-passing were employed.

MR. WILLIAM FOULKE JONES, Member of the Society.—I am somewhat surprised at the small amount of water which the Committee allow as waste, only about 20 gallons per capita. According to Professor Burr, there is a daily consumption of about 120 gallons

per capita in New York. The largest allowance made by European engineers, to the best of my recollection, is 60 gallons per capita, this even in the large cities of England where there is a considerable amount of water used for bathing purposes, and this also includes the amount which they waste. Now, if to the 60 gallons which they *use and waste* we add the 20 gallons which we are said to waste, and deduct from the 120 gallons which we consume, it leaves 40 gallons; or *our actual use of water*, not including waste, is 67% greater than both *use and waste* in Europe. I would like to know if Professor Burr can give us any idea why this is so.

MR. HERING.—Yes, sir. Sometimes the English gallon is quoted, and this quotation of 60 gallons, I think, is the English gallon, or about 75 U. S. gallons. We get the wrong impression very often regarding gallons from reading English reports. It has been observed that on certain portions of the East Side the consumption of water is about 25 gallons per head. That is characteristic of a certain class of European population. The class of people that live there are the same class found in certain European cities, and they do not use the water in the same quantity as we do. Such districts are found in London, Paris, Vienna and Berlin, where their per capita consumption ranges, speaking in our gallons, from 15 to 30 gallons per head per day. And there are other districts in the same cities where it rises to over 100 gallons per head. The question of consumption requires better analysis, and we are very grateful that last year has seen such an analysis made in this city, which I think was never before made so thoroughly. When this information is published you can see how greatly the consumption depends on the habits of the people, and particularly on the district you are considering, whether it is a hotel district, business district, wealthy residence district, etc.

MR. EDWARD L. HARTMANN, Member of the Society.—With reference to the great difference found in the rate per capita of consumption of water in various sections of the city, I believe that while the same may be due largely to the personal habits of the residents, there are also a number of other factors which enter into account. In the older sections of the city, especially the lower East Side of Manhattan, where the consumption per capita appears to be least, there are still a very large number of old-style dwellings, chiefly tenements, without modern plumbing. In these buildings there are no bath-rooms, nor stationary wash-tubs; in fact, very often all the water used by the families living on the same floor has to be drawn from a single faucet located in the common hall. All hot water used must be heated on the kitchen stove, and for bathing and washing, portable tubs have to be used. On the other hand, throughout the modern private houses and flats, where bath-rooms, station-

any wash-tubs and arrangements for hot and cold water exist, consumption will naturally be greater. There will be more leakage from defective valves, especially in connection with flushing tanks, and where servants are employed, very often considerable unnecessary waste; the consumption of hot water being usually limited only by the heating capacity of the boiler.

DR. JAMES C. BAYLIS, Member of the Society.—I would like to ask if the Commission has given any attention to the matter of an auxiliary salt water supply, whether that comes within the scope of their work, and whether they have any views concerning it which they would care to express.

PROFESSOR BURR.—The consideration of an auxiliary salt water supply was not within the scope of the instructions issued to the Commission.

MR. NOAH CUMMINGS, Member of the Society.—I should like to ask about the plan for carrying the water from the Esopus watershed under the Hudson River. As the pressure in the aqueduct at that point would be very high, the details of the method to be employed must be of considerable interest.

PROFESSOR BURR.—Water from the west side of the Hudson can be carried through pipes laid in dredged trenches in the bottom of the river; or the water may be conducted through tunnels under the river. Any one of a number of general plans is entirely feasible. The final details have not been studied.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

Paper No. 8.

THE MAINTENANCE AND REPAIR OF ASPHALT PAVEMENTS.

PRESENTED BY GEORGE W. TILLSON, Member of the Society.

MARCH 23D, 1904.

The cost of maintenance and repairs of engineering structures is second in importance only to the original cost. This fact was not recognized in this country till long after large construction works had been carried out. The demand for public improvements in a new community is always so strong and persistent that ultimate economy is often sacrificed in order to satisfy the present demand quickly.

This is as true of street pavements as it is of other engineering work. First cost and quickness of production have been too often considered, while maintenance and repairs have received very little attention.

But as the country has grown older, and conditions more settled, all engineering work has been planned in the spirit of true and ultimate economy.

The first asphalt pavement of any amount was laid on Pennsylvania Avenue in Washington in 1876-77. This was followed in 1878 by the Delaware Avenue pavement in Buffalo. These pavements were so successful that asphalt as a paving material was soon adopted by all the leading cities of the United States, to such an extent that there are now approximately 2500 miles of asphalt pavement in this country, nearly one-half of which is in New York, Philadelphia, Washington and Buffalo.

When this pavement was first laid, no one knew how long it would, or ought to, last. In order, therefore, to induce municipalities to adopt the material, it was agreed by the promoters that the contract price should include the cost of repairs for a term of five years. This was an arbitrary period, but it has generally been accepted as a proper one.

When these guarantees began to expire, there was presented to the different city officials the problem that has suggested this paper, *viz.*, "The Maintenance and Repair of Asphalt Pavements."

Asphalt is a compound and very complex substance. There is no intention to enter into a discussion of it here. It is enough for present purposes to say that it is a natural mineral pitch, fairly well distributed in its different forms over the earth's surface.

The first asphalt pavements were laid with material from the Island of Trinidad, and at that time it was supposed to be the only source of supply. But other deposits were found in California and Venezuela, and in 1895 pavements were very generally laid with asphalt from these localities.

Still later it was ascertained that asphalt could be obtained from the petroleum oils of California by distillation, and it is probable that a considerable amount of the bituminous pavements of to-day has been laid from oil asphalt.

Further deposits have been located in Mexico, Utah, Kentucky, Indian Territory, Cuba, etc., the material varying in its form, but containing to some extent the cohesive property that makes it valuable as a paving material. It does not follow, however, that all asphalt will make good pavements. What is required is that the material shall furnish sufficient cohesive strength to hold the particles of sand and stone dust together until the pavement wears out, without any disintegration.

As an example of the asphalts proposed for paving can be cited the fact that on February 2d the City of Detroit received proposals for twenty different varieties, in response to an advertisement for 1 500 tons, the price varying from \$15.98 to \$40 per ton. With such conditions and the known variations in asphalts, it will be a very pretty problem to decide which is the best bid.

MAINTENANCE.

In this paper, the word maintenance will be considered to mean, not simply repairs, but maintaining an asphalt pavement perpetually on a street, and the cost of maintenance will mean the cost of repairing a pavement during its life, and its complete renewal when worn out.

The following items must be considered when figuring on the cost of maintenance:

First cost.

Cost of repairs.

Life of pavement.

Rate of interest to be paid on bonds.

These being known, the cost can be obtained from the following formula:

$A + CI + \frac{R}{N}$ = amount to be paid each year to maintain a pavement perpetually when

N = life of proposed pavement,

C = cost per sq. yd.,

I = rate of interest,

R = estimated cost of repairs if distributed over entire life,

A = amount to be paid each year to equal C at end of N years.

It is very important that city officials know what this cost of maintenance is. With this knowledge, the financial officer of a city can tell for how long a period he should issue his bonds. With this knowledge, the engineer can tell when the cost of repairs is exceeding economical bounds, as where the cost of repairs is more than the cost of maintenance, true economy demands that a new pavement be laid.

It works out as follows:

The Borough of Brooklyn in 1903 laid approximately 800 000 yd. of asphalt pavement at an average cost of \$2.10 per sq. yd.; C then equals \$2.10.

Bonds of the City of New York are sold bearing $3\frac{1}{2}\%$ interest, so I equals $3\frac{1}{2}$.

The cost of repairing must be estimated, but it seems safe to call it 84 cents, assuming N to be 18, that the pavement will be under guarantee for 5 years, will cost 4 cents per yd. for the next 5 years, and 8 cents per yd. for the remainder of life. In the light of figures to be presented further on, this estimate may seem too high, but it is better to be on the safe side.

The life of an asphalt pavement is also unknown. According to the report of the Engineer Commissioner of Washington for the year ending June 3d, 1902, that city had resurfaced fifty-one asphalted streets whose average life had been fourteen years, but it also had at that time ninety-six pavements whose average life was twenty years.

According to the report for Buffalo for the year ending June 30th, 1903, there were in that city sixty-two pavements over fifteen years old, with an average life of seventeen years. Brooklyn has twenty-two streets over fifteen years old with an average life of practically sixteen years. N then is taken at 18.

If \$0.08568 be deposited each year and compounded at $3\frac{1}{2}\%$, it will amount to \$2.10 at the end of 18 years. Substituting, then, the equation becomes $.08568 + (\$2.10 \times .03\frac{1}{2}) + \frac{\$4}{18} = \text{cost of main-tenance or } \0.20584 . That is, if an assessment amounting to $20\frac{6}{10}$ cents be levied for each yard of pavement annually for eighteen years, the resulting amount will keep the pavement in repair and redeem the bonds at maturity, provided the cost of repairs and life of the pavement have been correctly estimated.

To relay the pavement will cost less than the original amount, so that only \$1.40 need be charged for renewals, instead of \$2.10. Applying the formula as before, the annual cost of perpetual maintenance is found to be \$0.15278.

Mathematically, then, when any street is costing annually for repairs more than $15\frac{1}{4}$ cents, it is time for it to be repaved. Other considerations, however, will often govern this, but it can be safely said that when the above limit is reached, the exact conditions demand the attention of the engineer. And if the records of each street are carefully kept, he will be able to weed out each year the expensive streets, and thus reduce the cost of maintenance to a minimum.

REPAIRS.

When the original guarantees on the early asphalt pavements began to expire, it was a serious question as to what was the best method of keeping them in good condition. At that time no city official knew anything about asphalt, and had only a vague idea as to where it came from. As a natural consequence, they looked to the original contractor for relief.

In Omaha, Nebraska, guarantees on its first pavements expired in 1888. After much careful study, and many conferences with the original contractors, an agreement was entered into by which the then existing pavements were to be kept in repair for an additional ten years for the sum of 8 cents per yd. of entire area per year. It must be remembered that at that time no asphalt pavement had been in existence fifteen years in this country. No one knew how long it would or should last, nor what it ought to cost to keep it in repair during its life. This contract was probably a fair one when all the streets were included. No doubt some cost more than the amounts received, but this was equalized by the low cost of others.

The City of Cincinnati, in the early days of asphalt, let a contract for repairing all streets between five and ten years old for 9½ cents per yd. per year, and for streets between ten and fifteen years for 14 cents, the cost to be figured in both cases upon the entire area of the pavement.

Buffalo is a city that early had a large amount of asphalt to keep in repair. Its plan has been to receive bids per square yard of repairs actually made, the contractor to maintain these patches for three years. Buffalo's last contract, however, provides for a one-year guarantee only.

In Washington still another system is used. There the work is paid for upon the amount of material used. That is, bids are asked for per cubic foot of wearing material and binder, the price to include all labor of cutting out and removing the old and defective material.

These four methods seem to be the only ones that have been used to any extent. Some cities have sought to settle the repair question by making the guarantee longer than five years, some ten and even fifteen years. Others specify in the original contract that the pave-

ment shall be kept in good condition for a certain price, for a fixed period, and think that they therefore insure cheap repairs. This is a fallacy, for if the contractor thinks the stipulated price is too low, he simply adds to the original bid enough to make himself good. This plan does, however, make certain to a city when it enters into a contract just what will be the cost of a pavement for a term of years. But all such methods do not solve the problem—they simply postpone its solution, as ten and fifteen-year periods elapse just as certainly as those of five years, but not quite so often; that is the only difference.

The objection to the Omaha plan referred to is that the contractor cannot form an estimate as to what the repairs will cost; he must simply guess. It is a well-established fact that bids upon an uncertain plan are higher than on a fixed one, so the contractor endeavors to guess high enough so that he shall not suffer, and the result generally is that the work is let at a high price. Then, too, it is impossible to keep records of the actual cost of each street, as, with a blanket price, a good street will show just as great an expenditure for repairs on the books as one that has cost three or four times as much. So that the engineer cannot tell from his records just what streets are costing more than they ought.

The Cincinnati method is about as bad. The only difference is that the contracts are made for shorter periods, so that a better line may be kept on the actual cost. Both of the above plans are open to the criticism that great friction can easily arise between the contractor and city official over the amount of repairs to be made. There may be an honest difference of opinion as to just how much should be done, and while the engineer will eventually prevail, all possibility of friction should be avoided.

The Buffalo plan pays for what work is done. The engineer orders the work, and the contractor does it without question, and is paid for it. It involves the measurement of a great many small and irregular patches, and, when a time guarantee is exacted, every patch must be carefully plotted in the office, so that it shall not be paid for again, in case of failure, before the contract shall have expired.

Another objection is the fact that the price per square yard is based upon laying a full-thickness pavement. Now, the surface of

the patch must be even with the old pavement, and if this, as often happens, is worn half out, the contractor receives full price, when he only furnishes one-half the material he expected to. This method, however, is the one that is most generally used, as will be shown later.

The plan of paying by the cubic foot of material seems to be one that is fair both to the contractor and the city. The only element of uncertainty is the labor, and, with a little experience, that can be pretty carefully calculated. Its success assumes that the inspector in charge of the work is both honest and intelligent. His returns of work performed must be taken by the engineer, as it is practically impossible to ascertain after a street has been repaired how much material may have been used. He must be intelligent, so as to order the proper portions repaired.

In Brooklyn early repairs were made on the square yard of entire-area basis, the contract being let yearly. The streets were arranged in groups, as nearly as could be told, of the same character, and a price asked for per group. In 1900, the last year this plan was in effect, the average cost was 15.93 cents per sq. yd., while under the cubic-foot process now in use this has been reduced much more than one-half.

An effort has been made to ascertain from the principal cities of the country just how much their asphalt repairs are costing, and what is a fair charge for the maintenance of an asphalt pavement. Not much satisfaction has been obtained, however, as few cities keep their records so as to be of very great value. Many of them say that a certain amount of money is allowed for repairs, and they do the best they can with that amount, so that when the actual costs are obtained they mean that so much money has been expended, not that such a sum has kept the pavements in good repair.

This is not right. It seems a safe proposition to say that no city should lay an asphalt pavement unless it can afford to keep it in repair. People expect it to be kept free from holes. A condition that might be considered very good with a cobble pavement will not be tolerated with asphalt. A tear or a rip in a silk gown looks infinitely worse than one in a homespun dress.

Detroit, Michigan, reports that some asphalt maintenance contracts expired there in July, 1903, where the prices paid were 20 and

25 cents per yd. per year for the entire yardage. On other streets, by the Buffalo method, the price was, in 1901, 1.33; in 1902, 1.14; and in 1903, 1.12 per sq. yd. This city now has about 357 000 yd. out of guarantee.

Philadelphia now has more than 200 miles of asphalt out of guarantee, or about 3 100 000 sq. yd. In this city an annual contract is made for repaving permit ditches, resurfacing small patches, and for resurfacing large areas. These prices were as follows:

	1902.	1903.
Permit ditches.....	\$2.75	\$2.49 per sq. yd.
Small patches.....	2.35	2.24 " " "
Large areas.....	2.05	1.89 " " "

The total amount, approximately, for this work was \$195 000 in 1902, and \$40 000 in 1903. Kansas City, Missouri, pays 1.50 per sq. yd. for patches.

In the Borough of Manhattan there are now about 235 000 sq. yd. of asphalt out of guarantee. In 1897 a contract was let for maintaining certain asphalt streets for a period of ten years, the price being the amount to be paid per year per yard of entire area. The prices ranged from 25 cents on Chambers Street, 15 cents on Fifth Avenue, between Waverly Place and Ninth Street, 13 cents on Liberty, Cedar, William, New and Nassau Streets, down to 6 cents on some of the streets in Harlem, where the traffic is not so heavy. In 1903 a contract was let on the basis of area actually repaved for 1.52 per yd.

Washington, Buffalo and Rochester, N. Y., are the only cities from which accurate information could be obtained of the cost of asphalt repairs since their first pavement was laid.

The following table shows this cost, also that of the Borough of Brooklyn, for 1902 and 1903. The figures show the cost per yard of all the streets at the different ages given:

Year out of	Guarantee.	Washington.	Buffalo.	Rochester.	Brooklyn.
1		0.65	0.91	0.76	2.50
2		0.77	2.61	1.83	2.46
3		1.80	3.18	3.75	5.23

Year out of Guarantee.	Washington.	Buffalo.	Rochester.	Brooklyn.
4	2.33	4.55	2.29	8.00
5	2.69	5.03	3.85	3.95
6	2.60	5.06	3.70	15.25
7	3.33	5.32	5.30	7.88
8	3.96	3.12	2.98	13.69
9	3.45	3.34	2.45	10.80
10	3.54	3.39	6.71	15.16
11	3.09	3.99	6.56	28.24
12	3.86	3.74	6.20	2.83
13	3.38	4.38		9.65
14	4.56	2.65		1.24
15	3.19	4.37		3.00
16	2.64	4.06		
17	2.01	1.84		
18	2.80	3.31		
19	1.87			
20	3.56			

The Washington costs are obtained from a paper written by Captain H. C. Newcomer, formerly Assistant to the Engineer Commissioner, District of Columbia, in *Engineering News*, February 18th, 1904, and are for the period terminating June 30th, 1903. The last contract had been made for a period of three years, the unit price being for standard asphalt surface $2\frac{1}{2}$ in. before compression, 67 cents per sq. yd.; for standard asphalt surface, measured in cart, 49 cents per cu. ft.; for asphalt binder, measured in cart, 25 cents per cu. ft. This is a reduction from 95 cents per cu. ft. paid in 1897 for standard asphalt surface.

The costs for Washington, shown in the table, are the costs of repairs made by the cubic-foot method, the cost of resurfacing by the square-yard method not being included. For instance, if a street containing 10 000 sq. yd. is kept in repair by the cubic-foot method for three or four years, then 1 000 sq. yd. resurfaced, then kept in repair by the cubic-foot method another terms of three years, and another 1 000 sq. yd. resurfaced, then kept in repair by the cubic-foot method for a term of years, and then entirely resurfaced, the

cost of resurfacing the above 2 000 yd. is not included in the figures as given, so that the table does not show the entire amount that has been expended on these streets since they were originally paved.

For the year ending June 30th, 1902, there was spent for minor repairs, approximately, \$45 000, and for repairs by the resurfacing method, approximately, \$80 000.

For the year ending June 30th, 1903, there was spent for minor repairs about \$58 000, and for resurfacing about \$62 000. So it would seem that the cost of maintenance on these streets would be nearly double the amount given in the table.

Captain Newcomer gives the average cost per square yard per year for the first five years out of guarantee 1.65 cents, for the second five-year period 3.78 cents, for the third five-year period 2.56 cents, and for the average cost for all years 2.8 cents. He also says that there are over 700 000 sq. yd. of pavements that are over 18 years of age, and that the average age of the areas resurfaced during the year ending January 1st, 1903, was slightly over 21 years.

The figures for Buffalo have been compiled from the report for the year ending June 30th, 1903. They compare very favorably, as will be seen, with those from Washington, and are based upon repairs in the last year of 3 117 364 sq. yd. The cost seems low, and, as the author had seen considerable in the public print about the condition of the asphalt pavements in the past few years, a letter was written to the engineering department, to which the following reply was made:

"The papers have complained occasionally of the condition of asphalt pavements, but I think not of repairs actually made. The complaints are, rather, because pavements wear out, and our appropriation has so little margin to cover all the streets requiring repairs."

It would seem, therefore, that this was a case where, to a certain extent, the facts are of money spent rather than of repairs needed. The records of Buffalo are very complete, and reflect much credit upon the engineers in charge of the Public Works Department.

The last contract made in Buffalo provided for completed pavements to be laid at \$2.25 per sq. yd., surfacing 97 cents, and for filling cracks 5 cents and 2 cents. Just why the two prices were

inserted for filling cracks the report did not state. This is the only case within the author's notice where any special price has been received for filling cracks.

The average price for resurfacing during the past ten years is \$1.33, while, as has been shown, the price for the last contract was 97 cents. This shows, as do all the other reports, that the price for this work is constantly falling.

In comparing costs of repairs in the different cities, it is absolutely necessary that these unit prices be also compared.

UNIT PRICES FOR REPAIRS.

	Cu. Ft.		Sq. Yd.	Yd. out of Guarantee.
	Top.	Binder.		
Washington.....	0.49	0.25	*0.83	2 286 786
Brooklyn.....	0.95	0.40	*1.61	1 227 084
Kansas City.....	....	....	1.50	....
Detroit.....	....	....	1.12	357 000
Buffalo.....	....	....	0.97	3 117 364
Rochester.....	....	....	1.28	450 907
Philadelphia.....	....	....	2.24	3 100 000
Manhattan.....	....	....	1.52	235 000

* Reduced to sq. yd. from cu. ft. prices.

The Rochester figures have been compiled from the report of the City Engineer for the year ending December 31st, 1902. The cost per square yard for resurfacing during 1902 was \$1.28. Rochester at that time had 450 907 sq. yd. of asphalt out of guarantee. These prices are low, and it will be noticed that the oldest pavement shows the smallest price per square yard. This is a pavement that was laid in June, 1885, and its entire cost per square yard during its entire maintenance has been 2.17 cents per year.

The author has had an opportunity of examining the Rochester pavements, and knows that they have been kept in first-class condition, and that the figures here given show the actual cost of such repairs as were necessary to keep the streets in good condition, and it would seem that these prices were the lowest of any that have been considered, when all things are taken into consideration.

The figures for Brooklyn are taken from the records of the last

two years only, as that is the term for which the present system of repairs has been in operation. They show a very marked increase over those of either of the other three cities, particularly over the Washington costs. The Brooklyn figures, however, represent what it has actually cost to keep the streets in good repair. By this, it is not meant that the asphalt pavements of the Borough of Brooklyn during the last two years have always been in good condition, but it does mean that at the beginning of each of the two years the work of repairs has been begun and continued systematically through the year, repairing all streets that needed it, so that at the end of the year they have been in good condition, but during the winter season, of course, in the older pavements, many holes have developed.

There are several reasons, too, why the cost of repairing asphalt pavements in Brooklyn should exceed that of either of these other three cities. In the first place, many of the older pavements were laid over cobblestones, and some over the old wood pavements. Of course, when the wood in the foundation decayed, the asphalt must fail, whatever its character at that time.

On other streets pavement after pavement has been laid upon each other, so that when portions of Bedford Avenue were repaved, a few years ago, bituminous pavement was found in some places to the depth of at least 12 in. It might be said that it would be economical to repave these streets, and this is true in the abstract. At the same time, it has been deemed best to use the repaving money more for the purpose of repaving the old cobblestone streets for which Brooklyn has been so famous, and keep the asphalt streets in good repair out of the repair fund, even if it might not seem economical.

Brooklyn streets, too, are narrow, a width of roadway 34 ft. being wide, and, when a double line of street-car tracks is laid in this roadway, it leaves only a space $9\frac{1}{2}$ ft. between the tracks and curb, so that the cost of repairs is made excessive on this account.

Many of the early streets were laid as pioneer streets, towards the outlying sections of the borough, so that an abnormal amount of traffic was brought to them.

The following shows the effect of street-car tracks on streets in

Brooklyn, both for the original cost, and cost of repairs for asphalt pavements:

Cost of pavement complete, 1903:	Per yard.
Streets without car tracks.....	\$2.05½
Streets with car tracks.....	2.42
Average of all streets.....	2.10
Repairs, 1902-1903:	Cost per yard.
Car-track streets excluded.....	5.31 cents.
Car-track streets	16.10 "
All streets	6.55 "
All streets, previous method.....	15.93 "

Then, too, it will be seen that the price paid in Brooklyn has exceeded that of these other cities, the cost for 1903 being 95 cents for wearing surface, and 40 cents for binder, while the last contract let in Washington, as has been shown, was 49 and 25 cents, respectively, although in previous years the cost was a little more.

There are also reasons why the legitimate cost of repairing asphalt pavements in Washington should be less than that in any other city of the country. In the first place, the streets are all well paved, and the asphalt pavements are pretty generally diffused over the entire city, so that traffic is not congested, and while a certain amount of traffic is a benefit to an asphalt pavement, especially in the earlier part of its life after the pavement begins to fail and holes have developed, it is worn out in proportion to the amount of travel that goes over it. Washington streets, too, are wide, and the traffic light, as it is not a commercial city, and in most cases the traffic is one that ministers to the wants of a people of homes.

The Buffalo costs are light, too. One reason for that has already been given, and it will also be seen that the price for repairs is low, and experience has shown that the unit price of asphalt repairs is consequently growing less in cities where any large amount has been let by contract.

Buffalo laid a very large amount of asphalt pavement at one time, so that the traffic over it is general, and not congested.

The cost of repairs in Rochester is low as referred to Brooklyn,

and it certainly must be admitted, deservedly so, as the pavements have always been kept in good repair. From personal observation, it would seem that the asphalt pavements of Rochester were as good as any that have ever been laid in this country.

Of course, no one can tell what it costs the contractors to keep their streets in repair during the guarantee period. It may be of interest, however, to know that two streets in the Borough of Manhattan, aggregating 11 000 sq. yd., laid seven years ago, on a ten years' guarantee, have cost \$2 200 per year during that time. The roadways of these streets are very narrow, with a single car track in the center. The obvious lesson from this is that asphalt is not a suitable material for paving these streets.

In this discussion upon the cost of asphalt repairs, all of the work has been done by contract. It would seem, however, that in a short time many of the cities containing a large amount of asphalt pavement out of guarantee must make some arrangements for making the repairs themselves.

There is no reason in the present stage of the asphalt market, or with the present knowledge of the asphalt business, why the city should not conduct its own asphalt work, as far as repairs are concerned, at least.

In many cities throughout the country controversies have often arisen between the city officials and the asphalt contractors as to what repairs should be made. When the asphalt companies have refused to make these repairs it has been impossible to have them made. The contract may be drawn with all the legal terms, and with all provisions governing such cases, but the end is always a penalty if the contractor does not do the work, and the infliction of a penalty does not put the street in good repair.

It is a well-known fact that even when asphalt companies are opposed to each other it is almost impossible to get one of them to perform any work in the way of repairing a pavement laid by their rivals.

The only practical remedy for this is for the city to do its work itself, and, with the vast amount of asphalt pavement that is being laid at the present time, it does not seem right that municipalities should be in a condition that is not entirely independent.

In the fall of 1903 the author was called upon to prepare a report for the Commissioner of Public Works of the Borough of Brooklyn upon the advisability of establishing a municipal asphalt repair plant in that borough, and quite a portion of the following details have been taken from that report:

In 1902 the City of Toronto, Canada, called upon its City Engineer to make a report on the cost of a municipal asphalt plant. A report was made to the Board of Aldermen, January 30th, 1903, that the approximate cost of a municipal plant with the capacity of from 1 500 to 2 000 sq. yd. per day would be \$25 000. No action, however, has been taken to construct a plant.

Detroit, Michigan, has been discussing a municipal asphalt plant for some years, and after many failures a contract has been entered into for a plant with an approximate capacity of 1 500 sq. yd. of asphalt pavement per day. The contract price for this plant is \$15 500, and it is expected to be erected early the coming spring. This plant is to be used for repairs only.

The City of Winnipeg, Manitoba, has had established a plant for the construction of asphalt pavement for four or five years. It has been very successful, and the City Engineer estimates that the cost of the pavement has been reduced a little below the public contract price. It has had no trouble in obtaining asphalt, or the necessary expert service to operate the plant and lay the pavement.

The cost of making asphalt repairs must be made up of three items:

First.—The fixed charges caused by interest, sinking fund and depreciation on the cost of the plant.

Second.—Material.

Third.—Labor.

The Borough of Brooklyn used during 1903, approximately, 70 000 cu. ft. of wearing surface in making its repairs, maintaining a little over 1 200 000 sq. yd. of pavement. A plant to produce that amount should have a capacity that would supply 50% more, so that the increase in demands made on the plant will be provided for.

The plant should be in operation from the first of April to the first of December; assuming that it worked 20 days each month, it would be used a total of 160 days. In order to produce, then, 70 000 cu. ft. per annum, the average production would be about 440 cu. ft.

per day. In the early part of the season, when needed repairs were numerous, it might be worked to double its capacity, so that a plant to keep in repair a million and a half or two millions of square yards of pavement should have an ultimate capacity of 1 000 cu. ft. per day.

The cost of the Winnipeg plant to date, including original cost and maintenance for five years, is \$17 398.97. The engineer, however, stated that this cost was probably 50% more than such a plant would have cost in the City of New York.

Reliable information has been obtained that a plant could be obtained in the Borough of Brooklyn, with the capacity above mentioned, at a cost not to exceed \$13 000. With the necessary rollers, tools, etc., that total estimated cost of the plant would be \$20 000.

The interest on this sum at $3\frac{1}{2}\%$ would be \$700. Allowing 10% of the cost of the plant for depreciation and repairs, there would be a total fixed charge of \$2 700 for interest and maintenance. On a basis of 70 000 cu. ft. per year, the cost for fixed charges would be 4 cents per cu. ft.

An asphalt containing 95% bitumen can, without doubt, be purchased at a price of \$25 per ton. In Winnipeg the price has run from \$25 to \$38.60 per ton, irrespective of the quality of the asphalt. The Detroit price has already been given, and there is no question that the cost in New York would be even less.

In order to make 14 cu. ft. of asphalt mixture there would be required:

1 100 lb. of sand, 300 lb. of stone dust, and 162 lb. of asphaltic cement, assuming same to contain 95% bitumen. This is a fair assumption for a California or a Bermudez asphalt. Trinidad asphalt contains approximately 55% of bitumen, and would accordingly require more asphalt per cubic foot of mixture.

Assuming the cost of sand to be at \$1.25 per yd.; stone dust, \$2.50 per ton, and the asphaltic cement \$25 per ton, the total cost for the material for 14 cu. ft. would be \$3.06, or 22 cents per cu. ft.

LABOR AT THE PLANT.

A plant that has turned out from 1 200 to 1 500 sq. yd. of asphalt per day has been operated with nine men. The plant estimated upon here would not require as much labor as one capable of laying 1 500

sq. yd. per day, but, to be on the safe side, labor at the plant has been taken at \$25 per day. This, for 160 days, would amount to \$4 000 per annum, or for 70 000 cu. ft., 5.7 cents per cu. ft.

LABOR ON THE STREET.

It is extremely difficult to estimate the amount of labor necessary to lay 70 000 cu. ft. of material in patches, as it depends wholly upon the character of the pavement repaired.

It can easily be seen that if one load of material will repair half a mile of street, it will cost much more per cubic foot for the labor than if ten loads had been used within this same area.

After careful observations, an estimate of 25 cents per cu. ft. has been given as a definite figure for the average of this work, including the hauling of the new and the disposition of the old material.

Fuel is an item which must be considered. Although somewhat difficult to estimate, it can be safely put as not more than 4 cents.

Making, then, for the total cost,

Fixed charges.....	4 cents.
Material.....	22 "
Labor.....	31 "
Fuel.....	4 "
<hr/>	
or	61 cents per cubic foot.
Adding 10 per cent. for contingencies.....	.06
<hr/>	
A total cost of	67 cents per cubic foot.

The contract price in Brooklyn last year was 95 cents per ft., or 28 cents in excess of this estimated amount. This, for 70 000 cu. ft., will amount to \$19 600, almost the estimated cost of the plant.

Quite a revenue, however, can be obtained by the city making repairs to plumbers' cuts, and, if it should be advisable, over corporation openings of all kinds. These prices would more than make up for any omission in the above estimate, and there seems to be no question that asphalt repairs need not cost more than 67 cents per cu. ft. in the Borough of Brooklyn, if intelligently carried out under the municipal government.

DISCUSSION.

MR. EMILIO AGRAMONTE, Member of the Society.—I would like to ask Mr. Tillson if any comparison has been made with the pavements in the City of Paris or some other European cities.

MR. TILLSON.—I have not, for the reason that the European asphalts are entirely different from ours.

MR. AGRAMONTE.—Is it a fact that in Paris the municipality repairs its own asphalt?

MR. TILLSON.—As a rule, they contract for a term of years for all pavement repairs.

MR. NELSON P. LEWIS, President of the Society.—I think the English practice is to let them have the original construction contract covering only two or three years, is it not, Mr. Tillson?

MR. TILLSON.—Yes, and then make a subsequent contract.

MR. ARTHUR S. TUTTLE.—In the formula which Mr. Tillson has prepared for the purpose of expressing the annual allowance for maintenance, I understand that the average yearly cost of repairs is assumed to be the estimated total cost of repairs during the life of the pavement, divided by the number of years of life. Since there is a variation from year to year in the cost of repairs, I wish to ask if the results shown by the formula would be materially altered if this term had taken the form of an expression of the actual present worth?

MR. TILLSON.—I do not think so. I reduced the total to an annual cost for convenience. To give the amount exactly and mathematically correct we should know the exact cost for each year. I have assumed what I thought it would average.

MR. WISNER MARTIN, Member of the Society.—There were two streets in this borough where the railway company was ordered to renew the track construction. They were old surface tracks, built with old-fashioned side-bearing strap rails on a wooden stringer, but before the railway company had time to comply with the order the asphalt was laid against this old wooden stringer and without any toothing stones. This method has been very disastrous.

The railway company practically resurfaced Forsyth Street for us. It removed so much of the pavement to relay water pipes and connect with the hydrants and to move a gas main, besides what was necessary to remove for its own tracks and feeder ducts that, in such a narrow roadway, it meant practically the renewing of the whole surface of the street. Chrystie Street was a similar case.

MR. LEWIS.—I have heard it stated that the asphalt contractors would find it profitable to lay pavements on Manhattan Island for

nothing if they could be assured a goodly amount of repairs and renewals, such as are necessitated by openings for plumbers' cuts, the laying of mains and the reconstruction of railroads. I imagine the contractors on Chrystie and Forsyth Streets may have been saved from serious loss by the rebuilding of the railroads in these streets.

MR. MARTIN.—There is no doubt that the contractor greatly underestimated in his bid the wear which would come upon the pavements of Chrystie and Forsyth Streets. The horse-car track in each of these streets was built with old-style center-bearing rails on a wooden stringer, and the specifications provided for toothing stones laid transversely on both sides of each rail. The wear due to traffic on these streets was so great as to compel the asphalt company, not only to restore the asphalt many times, but to renew the toothing for a considerable distance. The construction of the slotted tracks, however, relieved the contractor from this difficulty. As already stated, it was necessary to practically resurface these streets north of Grand Street. This is the entire length of them where there are tracks. The railway company was compelled to pay for the restoration of the pavement at the original contract price, so that the contractor's bid price was more than doubled, because more than half of the maintenance period had already expired. It must be borne in mind that the contract price included the laying of the pavement and the maintenance of it for fifteen years, in order to appreciate how vastly the repairs of this kind help out the contractor, as indicated by Mr. Lewis.

The specifications should be drawn in such a manner that the city will get the benefit of the profits from restoration of pavements over cuts, instead of the asphalt companies. This could be done by requiring the companies which make openings in the pavements to pay the city for the repairs. The city should then pay for the repairs as they are made by the asphalt companies at a price, as recommended by Mr. Tillson, per cubic foot of asphalt wearing material used. The price charged to the companies should be greater than the actual cost of the repairs, so as to provide for the profit. This system is already in use with reference to plumbers' cuts, except that the repairs are made at the contract price, and although they are very small as compared to the cuts made by the street railway, steam and other companies, a substantial fund has been accumulated.

MR. TILLSON.—I know of one street in the West that contained some 12 000 or 14 000 yards that was laid in December—a great part of it, I know, when the temperature was down to zero. I was told by the contractor that during the five years of maintenance it did not cost over \$500 to keep it in repair.

DR. J. C. BAYLES, Member of the Society.—I have already covered in a paper before the Society my views on this subject rather fully, and my comment on the paper just read would be this: I attach small importance to figures of cost and maintenance unless assured that the pavements are maintained in good condition, which, as a matter of fact, those of Manhattan are not. In this borough the condition of many thousand cubic yards of asphalt pavements is simply dreadful, and we enter the spring with some of our prominent streets and avenues in such condition that, unless I am very much mistaken, it would be cheaper in many cases to repave than to repair them.

I am interested in the speaker's conclusion, and perhaps would go a little further even than he has done. The speaker believes that the city or borough or municipality should make its own asphalt repairs. I believe that a city should not exact from a contractor any maintenance contract whatever. It should buy its pavements as any other merchants, at the best price it can; should guard against fraud as well as it can, and should keep a record of what it costs to repair, and do that repairing itself in a systematic way the moment it is needed, and not wait until what begins as a depression has become a great area of concavity. The reason for this, the fairness of it, is perfectly evident to any one who knows why pavements deteriorate. Consequently, no contractor can calculate the wear of a pavement, because the traffic which he counts on at the time he lays it may materially change by reason of the closing of other streets or by the opening of new sections. A great volume of new traffic may go through that street the moment it is opened with a new pavement. He has to allow for that. Another factor of great importance which he cannot take into account is what the gas is doing. The asphalt pavements of New York are being rotted in spots all over the city by leakage of the gas mains, dissolving the binder and allowing the wearing surface to bowl and squeeze the binder out into the sand, or whatever lies underneath. That is a factor which no contractor for asphalt pavements can by any possibility calculate, because he don't know what will happen to the mains. He simply knows that they will leak and that the gas will work up, attack his binder immediately and rot it so that nothing will harden it again.

I am of the opinion that the most satisfactory procedure for a city is to buy its pavements discreetly, have them put down by contract, take them when they are done if as specified, maintain them the best it can, do the repair work as it is needed, and charge a fair price to every corporation that breaks a pavement for correcting the damage done, and possibly thereby recover a large portion of the cost of its work on small repairs, if made when they appear to be neces-

sary. A record of a city's pavements should show how it may guard against its being imposed upon a second time by a contractor.

MR. SAMUEL C. THOMPSON, Member of the Society.—I do not think that much can be said from the Borough of The Bronx on repairs to asphalt pavements, as there are but few streets out of guarantee, at the present time, and none under contract for repairs. Other streets will come from guarantee during the year, and steps are being taken to make a contract for repairs on the same. The streets having been maintained and repaired by the contractors up to the present time, there are no facts available as to the cost of maintenance or repairs, and no figures have ever been compiled in the Bureau of Highways.

MR. LEWIS.—Mr. Tillson did not refer in his paper to something I hoped he might speak about, and that is the evident damage to asphalt pavements which has occurred during the severe winter through which we have just passed. It is not a question, perhaps, which was properly included in his subject, which relates to the cost and the method of repairs to asphalt, but the observation I have had the opportunity to make would indicate that we have probably just passed through the most trying winter for asphalt pavements which most of us have experienced, and I would like to ask Mr. Tillson if he has not observed this damage himself, and if he attributes it to the very severe weather. Cracks have developed in pavements, three, four or five years old, that have not before shown any tendency to crack. They have developed during the last few months, apparently, and it seems to me they can be attributed to the exceedingly cold weather which we have had.

MR. TILLSON.—I would say that I have observed that same thing. Pavements which have been down seven and eight years and never cracked show them this year, and I attribute it to the severe winter, but this must be remembered: Pavements ought not to begin to crack, naturally, until they get something like that age. We are making at the present time an inspection of all the pavements that have been laid recently to find whether it is one contractor's pavement that is cracking, or whether it is a general cracking over the city; whether most of this cracking is due to the weather, or is due to the kind of asphalt, or to the way it has been laid. We have had quite a number of cracks show up this spring in pavements that were laid last year, and of the kind of asphalt that, previous to this spring, it has been almost impossible to find a crack in, so that as far as we have got at the present time in the inspection I cannot attribute it to anything else than the severe weather and perhaps some defect in the laying, because we find that on some streets the contractor's pavement will be cracked where the pave-

ment was laid last year, and on another street not. That thing must be analyzed, taking the width of the street into consideration, because that has a great deal to do with it. We have not data together enough to form a conclusion on that, although I think you are absolutely correct in saying that there are a great many cracks this year that would not have been in existence had we experienced such winter as we had a year ago.

MR. GEORGE J. BISCHOF, Member of the Society.—I would like to ask one question. From the point of view of the maintenance, what are the conditions that make an asphalt pavement the most probably correct pavement? I ask it for this reason: Streets with large traffic, like Eighth Avenue, Manhattan, get into bad shape; now, from the point of view of the expense of keeping asphalt pavements where there are car tracks, would it not often be best to have a good granite block pavement? I mean a granite block pavement with concrete foundation. The question applies to where there are car tracks and the grades are nearly level. Will Mr. Tillson kindly consider this question?

MR. TILLSON.—The gentleman has asked a pretty broad question. It is a question which can be discussed at length. Better is not an absolute expression. It depends on whether you want a pavement that will last and that will be economical, or whether you want one that is smooth and comfortable to use while you have it. Now, there are a great many streets that have asphalt pavements on them that are not economical. I do not consider that asphalt is an economical pavement as a whole. There is no question in my mind that in a great many streets granite would be more economical. Of the street referred to, Eighth Avenue, New York, which is probably the most celebrated and best known asphalt street in the country, it has been asserted a great deal by opponents to asphalt that it was being repaired at one end while it was being laid at the other. The question of the better pavement, whether asphalt is a better pavement for a street, depends a great deal upon what the conditions are on the street. Now, while I think a stone pavement would be much more economical on Eighth Avenue than an asphalt, still, I think, from the character of the street and the use of the street, and the character of the business on the street, that it can afford to pay for an asphalt pavement rather than for a granite.

MR. MAX L. BLUM, Member of the Society.—When Mr. Tillson speaks of economical pavements, does he take into consideration the wear and tear on the vehicles and the tractive power which would be required to draw a given load on those streets?

MR. TILLSON.—Yes, that must be taken into consideration. I tried to figure that out mathematically a few years ago, but found it a pretty difficult proposition. I tried to get the information from

some business houses in Brooklyn. When our asphalt pavements had increased, say, from 10 to 15 miles up to 50 or 60 miles, I got information from them that their repairs had very greatly decreased; just how much they decreased I could not get. I had the opportunity of my life almost on Fifth Avenue. I tried very hard to find out from the Fifth Avenue Stage Company how much it cost them for repairs before the asphalt was laid, *i. e.*, Fifth Avenue with a granite pavement, and then what difference they found in maintaining their horses and vehicles after it was paved with asphalt, but just about that time the company changed hands. I think the older people would have given me the information, but the new parties would not. I was sorry not to get it, as that was probably the best opportunity of comparing it. It would be very interesting to know the facts.

MR. LEWIS.—There is no question but that the people want pavements which are smooth, quiet, impervious to water, and sanitary. The petitions that have been presented during the last couple of years for pavements that people have to pay for very rarely call for stone block or other noisy pavements. Occasionally, on streets subjected to heavy business traffic, granite block is asked for. I have in mind one street in Long Island City, near the river front, where a petition was sent in for a granite block pavement, which was authorized. Shortly after followed a petition that the resolution for the granite block be rescinded and another one passed for substituting an asphalt pavement. Now, it happens that this street is within a block or two of the Barber Asphalt Company's plant, but I do not think that circumstances had anything to do with the change in sentiment. People will not tolerate noisy pavements. You will remember when Fifth Avenue was paved with granite block, many years ago. It was thought they were getting the finest pavement available. I suppose the cost per square yard expended on pavements in Fifth Avenue, in Manhattan, probably exceeds that of any other street, always excepting Broadway. But the granite block did not last many years. It became absolutely intolerable and people in these days, with high-strung nerves, simply cannot stand noisy pavements.

MR. C. D. POLLOCK, Member of the Society.—In regard to the extreme winter weather affecting the pavements, I have noticed a number of places where, in several suburban streets, especially around manholes, the whole pavement seemed to have lifted without cracking, as much as 1 or 2 in. I think probably the water got into the clay subsoil and the extremely cold weather did the rest. In these sections there is a layer of clay just under the concrete foundation. On streets where the subsoil is gravel, I have not observed any general lifting of the pavement.

MR. HENRY W. VOGEL, Member of the Society.—I have been waiting to hear a comparison between sheet asphalt pavements and block asphalt pavements. In Manhattan quite a number of streets are paved with block asphalt. It appears to me that the asphalt blocks or bricks could be made very durable where the conditions are most favorable to their manufacture, and probably repairs of a block pavement could be made better than of a sheet pavement. I thought perhaps something would be said here this evening about the comparative durability of the two pavements. I should like to hear something on that subject.

MR. TILLSON.—I have had very little to do with the asphalt block pavement. I think very favorably of it, however, and it has not been used in quantity enough or in cities enough, that I know of, where you could get an idea of the cost of repairs. I imagine, however, that the cost of maintenance on it would be much less than on sheet asphalt. There is this difference between the two. With the asphalt block, when it comes to be worn, you would probably have to resurface or relay the entire part, because, when a block is worn down one-half, you cannot put in a full-depth block, while with the sheet asphalt it is like repairing a ship, for instance. You can keep on repairing the sheet asphalt forever. You could lay a certain amount this year and a certain amount next year, and keep it up continuously the same as you could a ship. There might be no portion of the original pavement left after 25 years. You could not do that very well with the asphalt block. My opinion is that the cost of repairs for asphalt block would be materially less than the sheet asphalt, but the first cost is more, for the reason that the blocks have to be made at one central point and then carried the entire distance by some kind of transportation to the particular city or street where they are to be used. The asphalt blocks being made up here on the Hudson have been carried to Cuba and up the Amazon and other South American points, where they have been laid. They carry the blocks to any place and have the benefit of a smooth pavement, and can repair it without any expert labor and without any special plant. That is another advantage of the asphalt block over sheet asphalt, apart from the possibility of laying it on much steeper grades than you can a sheet asphalt.

MR. MARTIN.—I should like to say that, although we have no figures for the maintenance of block pavements, that the companies have bid against the sheet-asphalt companies and have won contracts. There is this objection to them: They wear very unevenly. The wear is not at all even over the whole surface. They have the advantage, however, that because of the manner of joining them they are less slippery; they seem to give a foothold for a horse and can be laid on much steeper grades than the sheet asphalt.

MR. LEWIS.—Can you tell on what streets the block-asphalt pavement company won and what the maintenance period was?

MR. MARTIN.—I think that for West Seventy-seventh Street was 15 years, and on West Seventy-sixth and West Seventy-ninth Streets for 10 years.

MR. TILLSON.—Well, that is a long maintenance. I was going to say about the asphalt block that you will find the same difference in asphalt-block pavements that you will in sheet-asphalt pavements, *i. e.*, some will wear well and some poorly. I have seen an asphalt block down five or six years that was practically in as good condition then, as far as service and use were concerned, as when it was laid. I have seen other asphalt-block pavements down two or three years, where the blocks themselves have gone to pieces. There ought to be more uniformity in asphalt-block pavements than in a sheet-asphalt pavement, because the blocks are supposed to be made in exactly the same way, the same amount of material and the same pressure applied to each block, but there does seem to be a variation in them. Sometimes they wear as smooth as a sheet asphalt.

MR. WISNER MARTIN. (By letter.)—I wish to express my admiration of the very evident, arduous and painstaking work of the author in deducing a formula which may be used to determine the economic value of pavements laid in different cities and under different conditions, and in standardizing the cost of maintenance of asphalt pavements. I think he has added something of permanent value to the general fund of engineering knowledge. This society also is to be congratulated that he has chosen to present this valuable paper before it.

It seems to me that it would be carrying out to some extent the purposes for which this Society was organized if a committee were appointed by the President to draw up a blank form of inquiry, to be sent to the cities which have laid a considerable amount of asphalt pavement in the different parts of the United States, for information regarding their experiences with asphalt pavements, the cost, durability, etc., so that the information could be compared on a common basis. This is certainly a subject which this city is greatly interested in at the present moment, especially because of the problems to be solved as to the best means of keeping the pavements in repair after the original maintenance period has expired. It is important to know, under the practical conditions of actual wear in the roadways, which kinds of asphalt are most durable.

In this connection the author says: "As an example of the asphalts proposed for pavement can be cited the fact that on February 2d the City of Detroit received proposals for twenty different varieties in response to an advertisement for 1 500 tons, the prices

varying from \$15.98 to \$40 per ton." He adds: "With such conditions and the known variations in asphalts, it will be a very pretty problem to decide which is the best bid."

Information also ought to be asked for regarding the amount of street travel and the general kinds of travel; for instance, whether light vehicles or heavy trucking predominates in each case.

In case this suggestion meets the approval of the President, I hope he will appoint Mr. Tillson chairman of the committee and Mr. Clarence D. Pollock a member.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

Paper No. 9.

THE CONSTRUCTION OF PUBLIC SCHOOL BUILDINGS IN THE CITY OF NEW YORK.

By C. B. J. SNYDER, MEMBER OF THE SOCIETY.

PRESENTED APRIL 26, 1904.

Before we plunge directly into the subject of construction, let us, for a moment, as is habitual with the craft, look into the whys and wherefores of the constructing, at the public expense, buildings costing in the aggregate millions of dollars, which yet cannot be classed as works of necessity and commerce, such as sewers, streets, docks, bridges, etc.

We are unanimous in our belief that to the establishment and development of our peculiar system of free public schools is due, in a very large measure, the phenomenal absorbing and welding power of our country, taking, as it does, all peoples of the earth and transforming them into citizens; citizens who hold the country of their adoption in such high esteem as to be willing to make any sacrifice therefor that may be expected of one native born.

I use the word "peculiar" in describing our public schools because I wish my hearers to bear in mind that they are for the children of the rich and poor, who are taught in the same class room, which fact alone always causes comment among foreigners who visit us.

On another point we are also unanimous—that the advanced position held by our country to-day among the nations of the world, and which is causing some of them to turn uneasily towards

us in a spirit of irritated inquiry, is due, in a large measure, to this same system of compulsory, though free, education for every boy and girl in the country.

Let us, for a moment, observe some of the opinions held on the subject by some of the members of the Mosely Educational Commission, which visited this city last fall.

Mr. Alfred Mosely, an Englishman by birth and training, who amassed a great fortune in the South African or Cape diamond fields, admits that this was made possible only through the assistance given by trained American engineers. He states that it was the success of these engineers which turned his attention to the United States, leading him some time ago to pay a visit here for the purpose of seeing what sort of a country it was that was responsible for sending so many level-headed men to the Cape. In his report just published he writes:

"I spent some months in the country investigating, and was astounded at what I saw around me, not so much at the state of development that had been reached at that time as at what I discerned of the future. I felt that a country teeming with such natural resources must, in the hands of capable men thoroughly acquainted with their business, play an important part in the future of the world, and was bound to exercise a far from negligible influence upon the industries of the United Kingdom. So far as I was able to ascertain, the form of education given in the United States is responsible for much of its success, and I returned home determined, if possible, to get together a party of experts to visit the country and test the soundness of my conclusions."

The reports of the members of the Commission thus organized, who spent several months in this country visiting cities, towns and villages throughout the land, makes most interesting reading.

They do not say outright that our position among the nations of the world to-day is due to our system of education, and to prove this several of the gentlemen, among them Mr. Mosely himself, quote the remark made by President Roosevelt at his reception of the commission at the White House, when he said, "Education may not make a nation, but a nation would certainly be ruined without it," but in the same paragraph Mr. Mosely says: "It is felt indeed throughout the United States that education is their safety and salvation."

National or racial prejudices are hard to overcome, and we cannot expect an open admission from the members of the Commission that the supremacy of this country in commercial or other lines is due to our system of free public education, but everywhere throughout the reports are observations such as that made by Dr. Jepson, that the "second general impression made upon me was again astonishment at the universal desire for education and the best education, among all classes of the commonalty."

Mr. Whitbur and others make a special feature in their reports of the high educational qualifications required of the apprentices and others entering the service of our largest and most successful industrial enterprises, broadly intimating that in this lies the great success of the works. More than once is there mention made of the amalgamative or welding effect of our free school system in making successful citizens of the almost incredible horde of immigrants which has poured into this country, one boldly saying that "it is the one thing which has stood between the country and dissolution through anarchy."

Nowhere does this remark apply quite so strongly perhaps as in this city of ours.

The public schools, elementary and secondary, have on register at this time a total of upwards of 500 000 pupils.

Their mental and physical well-being is cared for through the Board of Education, consisting of forty-six members appointed by the Mayor, of which, under the Charter, a certain number must be taken from each borough. Further, the city is divided into forty-six local school board districts, each borough having the same number of districts as it has members of the Board of Education.

Each local school board district has five members, resident therein, and appointed by the President of each borough.

It has been held from time to time that the Board of Education was not a department of the city government, but a separate and distinct corporation. The correctness of this view has been made very plain through a recent decision of the Court of Appeals.

Nevertheless, it is to the city authorities that the Board of Education looks for almost all of the enormous sums of money necessary each year, not only for the maintenance of the schools in

operation, but to care for the enormous yearly increase, the increase for the opening of the fall term last September being upwards of thirty-five thousand children.

To assume that these are all native born is preposterous, especially when there are school rooms of the lowest grades in which there may be twenty different races represented, many of the youngest being ignorant of the English language.

It is vouched for as a fact that immigrants frequently present their children for enrolment in our public schools within twenty-four hours of entrance to this country, cases having been found where their friends have conducted them almost direct from the Barge Office to the schools.

Notwithstanding our alertness in some things, yet in the matter of caring for the annual increase, this city, as well as Boston, Buffalo, Detroit, Chicago, St. Louis and a number of others, has failed to read aright the indications that the increase of school population would at least be proportionate with that of the increase in population of the city, and that it would grow greater with the country's prosperity instead of diminishing.

In fact, prosperity or depression seems to make little difference. as long as the peculiar urban movement holds the force it has had for the past ten or more years.

The result is that school buildings were not provided, and last fall there were 45 000 children who could not find admission, save through the establishment of part-time classes, thus putting 90 000 children on part-time basis.

It would have been possible several times to have caught up with the deficiency and have provided for the future, only it would seem that it is impossible to have two successive years of great activity in school house building.

Thus, the activity of 1897 was succeeded by that of the uncertainty due to consolidation in 1898.

Later cases are similar, except that the record-breaking year of 1902, during which contracts were let to provide nearly 48,000 sittings, was followed by last year, when, though funds were in hand, yet, owing to labor troubles, but little could be accomplished. At the present moment great activity prevails in the preparation of

plans and the letting of contracts for new buildings and additions to existing structures.

We now have buildings under contract to furnish about 80 000 new sittings, or more than the entire school population of the City of Boston.

Not only must the 90 000 children on part-time be cared for, which will require 45 000 seats, but the increase for September next, estimated at 35 000, and for September, 1905, estimated at 40 000, or a total of 120 000, must be put under contract before the solution of the question can be reached.

There is no doubt but that our present Mayor, in the first year of his term, will see to it that this is an accomplished fact before he will rest content.

What method is pursued in accomplishing such a vast amount of work?

The necessity of increased school accommodations having been demonstrated to the entire satisfaction of the Board of Estimate and Apportionment, an issue of corporate stock is approved and placed to the credit of the Board of Education, which proceeds to select the sites most urgently needed.

The site having been selected with reference to the immediate needs of a district and approved by the Board of Education, it is also approved by the Board of Estimate and Apportionment, either for direct purchase or through condemnation proceedings.

The City Superintendent of Schools, having ascertained the need of any particular section, makes a report thereon, stating the number, sex and grades of the children to be accommodated, and indicating any special equipment which he may deem necessary or expedient.

The report and recommendations having been passed upon by the proper committee, it is then turned over to the Building Bureau of the Board.

The architect of the Board of Education is given the title of "Superintendent of School Buildings," and upon him devolves the preparation of plans and specifications for the work, and the supervision of construction, together with the supervision or care of the six hundred school buildings of the greater city, as to their repairs or maintenance in a sanitary condition.

He has as his principal assistants a deputy superintendent in each borough, each of whom must be either an architect or an engineer. The work of repairs and maintenance alone of the present buildings, covering as they do approximately 350 acres of floor space, is in itself an enormous task, being used, as they are in many cases, both day and evening. No class of buildings, either public or private, is the subject of such close observation as to all conditions as the public schools, owing to the strong interest that attaches to them in the public mind.

Construction, therefore, must be, not for a time, or, as in private enterprises, until the property can be disposed of, but it is ever present, where all can see and criticise and, what is more, know, if anything be wrong, where to place the blame. Careful design and planning is therefore of the greatest moment, and must be thorough at every point.

In order to accomplish this, he has so organized the Bureau under his charge that the work under each deputy superintendent is subdivided into six divisions: 1, Design and planning, including general construction; 2, Heating and ventilating; 3, Electricity; 4, Plumbing and drainage; 5, Furniture; and, 6, Inspection and records; each division being in charge of a chief, and while co-ordination of work of one with another is encouraged or, rather, insisted upon, yet, on the other hand, interference is prohibited.

Formerly, great care was exercised in choosing a site, in order that there might not be encountered any obstacles in the securing of good foundations. Latterly this has been ignored altogether, as in many of the solidly built-up portions of the city the only unimproved building plots have been those where the question of the depth and character of foundations was such that no private owner cared to undertake it.

As the work of general construction is bid for at a lump sum, great care has to be exercised in the preparation of the plans, particularly with regard to the foundations, that the work actually to be performed shall be carefully shown and explained.

After the plans are far enough advanced so that the locations of bearing walls, piers and columns are known, borings are obtained of the ground at center points, under all piers and column

footings, and at such other places under bearing and other walls as judgment may dictate.

Borings are made by two methods, pipe and water jet, and auger, the last being used only in such cases where the results of the first are considered to be unreliable.

In both methods the element of human equation enters very largely, yet the failures, *i. e.*, where the information given was found to be incorrect, have been barely 2%, and in one of the instances which goes to make up a failure, the engineers assumed that because rock was located on the surface of two-thirds of the plot and piled over nearly the balance thereof that the entire location was the same as indicated by that portion which was exposed.

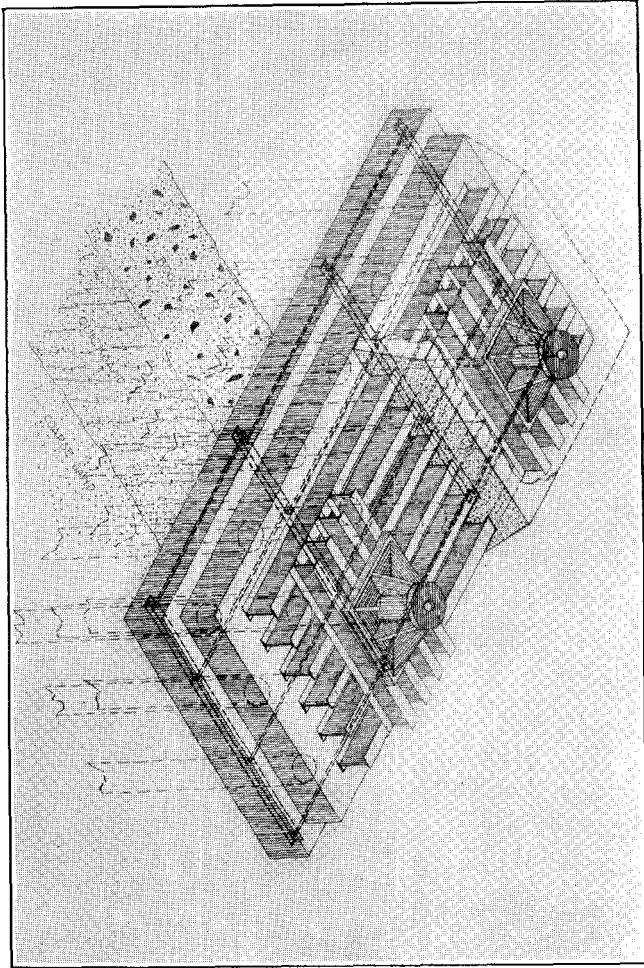
With the increased knowledge of our requirements and through frequent consultations, the engineers are enabled to convey to us a rather accurate idea of sub-surface conditions, and with this before us the nature of the foundations is then decided upon in a general way, pending the completion of the plans for the superstructure.

The sub-surface condition of Manhattan Island is admitted to present problems of the greatest variety, all of which are familiar to you through daily contact.

One of the methods employed in pile foundations by us has interested some of the members, who have asked that I illustrate it. Briefly, it is the practice of anchoring or bonding the concrete about the heads of the piles in a pier, before the granite capping is put in place, particularly where there are indications of a fill and we have heavy loads to carry. We have adopted this precaution after long and careful observation of the lack of strength transversely in concrete, applied, as it is, under great disadvantages, with the corresponding difficulty of proper work or inspection, and it has proven satisfactory in every case.

Some years ago I was called in to inspect a pier under a warehouse, the foundations of which rested on piles. The pier was semi-detached and showed cracks and splits, both vertical and diagonal, widest on the floor level and dying out from 3 to 5 ft. above the floor. Excavation made under the usual awkward conditions showed that the granite capstone and the concrete beneath were both badly split. The pier was shored up, the damaged work,

PLATE II.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SNYDER ON PUBLIC SCHOOL
BUILDINGS.



MAP

which was of good material and workmanship, removed, the excavation deepened and the piles, some twelve in number, were carefully examined. Some were found to not have been driven vertically, but the angle of deflection of the point of the pile could only be guessed at, as it is well known that in the event of striking an obstacle while being driven that it may bear no relation whatsoever to the angle of deflection from the vertical of the head of the pile.

A steam hammer not being in such general use at the time as to be readily obtainable, recourse was had to the use of hydraulic jacks to test the piles, the thrust being taken up by the pier above. There was no perceptible movement, although the power applied to each pile exceeded its proportion of the working load.

After carefully considering the matter, I had made iron rods with large anchor plates, and embedded them in concrete about the heads of the piles, as shown in Plate II.

The work was replaced, with results that were entirely satisfactory, as no further movement took place.

The cost of the anchor rods, if introduced at the time of construction, is very slight, and eliminates the only uncertainty of an otherwise very desirable and satisfactory form of foundation.

Plate III shows the foundation, or the piling plan, of Public School 37, in The Bronx. The building has 150 ft. frontage on two streets by 200 ft. in depth. The number of column foundations is due to a change made in planning, in order to avoid the criticism, which, for a number of years, has been leveled at the public school buildings of this city because of the formation of assembly rooms by the use of movable partitions between several of the classrooms, it being considered impossible to properly conduct exercises in these classrooms because of the readiness with which sound passes from room to room. In the buildings of this type, occupying spaces, as they do, between the avenues and extending through from street to street, I have utilized the basement beneath the surface of the play yard for an assembly room, it being readily accessible from the street for the use of lecture purposes, also from the school building, the outdoor play yard overhead being supported by columns passing through the auditorium or assembly room.

This building is planned to be four stories in height, but the

one at Forsyth and Orchard Streets, south of Hester Street, will be six stories in height and will have two auditoriums in the basement, thus making use of every inch of the property, which will cost in the neighborhood of \$400 000.

In designing the Wadleigh High School (Plate IV, Fig. 1), which is of the same general type, we were confronted by the rather peculiar condition that the window openings, which are 16 ft. in width, continued down to the basement, which, as it had no cellar beneath it, brought the space between the window sill and the bottom of foundation within very narrow limits. In order to prevent the difference in settlement which inevitably would have taken place at the piers, we decided to carry them down independently, and therefore placed a girder just above the level of the foundations, extending from pier to pier beneath the window openings, with instructions that the space beneath said girder was to be left entirely free and unobstructed until the completion of the building, when it was to be filled in solid with concrete. This was followed with very successful results.

In order to furnish a continuous record of the progress of the school buildings under construction, it is customary to have photographs taken thereof at intervals of about two weeks, and many such photographs are extremely interesting as illustrating the various methods of construction, copies of some of them having been requested by colleges for demonstration purposes.

Plate IV, Fig. 2, is New Public School 62, Hester, Essex and Norfolk Streets, six stories in height, furnishing accommodations for nearly 5 000 children, the land alone costing the city about \$600 000 under condemnation proceedings. Naturally, with such expensive property, it was necessary to make all the use thereof which the situation might demand, and it was decided that the best place for the auditorium would be in the basement, occupying what otherwise would be waste space. In order to do this and properly install the heating and ventilating apparatus, it was necessary to construct a sub-basement under a portion of the building, this bringing that part of our foundation down to about 29 ft. below grade, the balance extending 19 ft. below grade. The borings were made in July, 1903, going down to a depth of 34 ft.

PLATE IV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK,
SNYDER ON PUBLIC SCHOOL
BUILDINGS.



FIG. 1.—WADLEIGH HIGH SCHOOL.

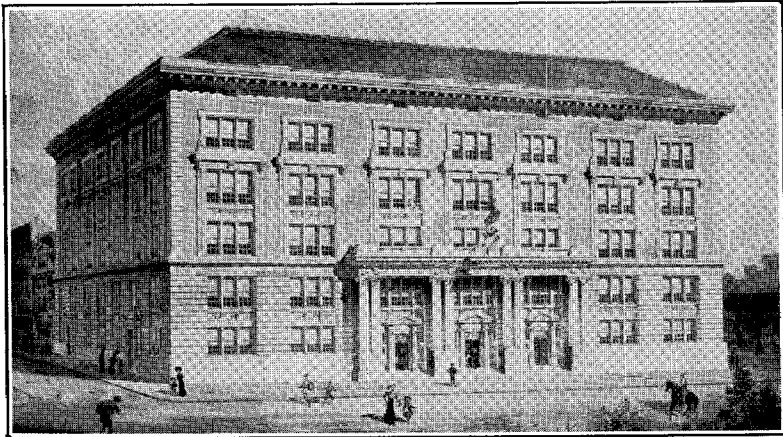


FIG. 2.—PUBLIC SCHOOL 62, MANHATTAN. HESTER, ESSEX AND NORFOLK STREETS.

without water. Excavation for the footings of the sub-basement were made last month, and water was found at the 28 ft. 6 in. level. The material upon which the building will rest is red sand and glacial drift, common to that section of the city, and is considered to be good material upon which to lay foundations.

We had figured our loads at 4 tons to the square foot bearing surface under the foundations, and as it appeared that a part thereof would rest upon sand permeated with water, and another portion, figured for the same load, upon sand which was apparently dry, I immediately raised the question as to whether or not there would be any difference in the rate of compression of material beneath the two portions of the structure. The opinion was advanced that the presence of water was due to the severity of the winter, the bulkheads having frozen up, thus preventing the surface water from finding free outlet into the rivers. This appeared to me to complicate the case, for if the presence of water might be for perhaps thirty days out of an interval of two years, we might surely expect to find an unequal settlement of the foundations due to this cause, and I therefore should like to take this matter up in the discussion which will follow the reading of this paper.

This is not an isolated case, as the varying water levels is well illustrated by the facts which have developed in reference to the school building at Hubert and Collister Streets. The water levels were plainly shown in photograph taken during construction, at the time the city declared the contract abandoned.

Very recently, the engineer who made the usual borings for this building was called in consultation with reference to the foundations of a building two blocks east, and found that the water level has dropped about 6 ft., caused, it is thought, by the installation of a pumping plant by a factory in the immediate vicinity. Thus, as all the buildings in the neighborhood are resting on piles, and the water level has dropped, therefore the piling is exposed to the air. The question naturally arises as to what methods will have to be taken to protect the building, and also as to whether or not the party or parties causing the expense through the lowering of the water level is responsible therefor.

The question of foundations is naturally a most important one,

and it is refreshing from time to time to observe the methods in use in the good old days when work was said to be "done on honor."

Some little time since it was reported that there were recent indications of cracks and settlement in the line of columns and girders at Public School 38, Clarke Street, near Broome. There was no apparent cause for any movement taking place, but, in order to be sure, I directed that the columns and girders through the center of the building be shored up and the column foundation excavated in order to ascertain, if possible, the cause of the trouble. There was nothing apparent excepting that the footings were in five pieces instead of one, but as they had been in place for nearly forty years, there appeared to be no reason why there should be any recent settlement. While considering the question, there was observed a hole in one corner of the excavation in what was supposed to be virgin soil. Further investigation disclosed the fact that the footing of this column had been resting upon an old well, which had been covered over with about 18 in. of earth. Plate V, Fig. 1, is from a photograph looking directly into the excavation, a candle having been used to permit of focusing the camera.

As another illustration of what may be considered old-fashioned construction, done otherwise than "upon honor," may be cited the placing of an iron column directly upon the floor beams, as shown in Plate V, Fig. 2, taken during the recent investigation of the cause of the settlement of old Public School 31, Borough of Manhattan. Other matters noted at this time were the omission of the key from a splice made on a girder over a column, which permitted a longitudinal movement of the girder and the rear wall of the building to the extent of the width of the key, that of about $2\frac{1}{2}$ in. The girder was sheathed at the time it was uncovered, and there could have been, therefore, no possibility of the key having recently been removed. In another tier it was found that a column on the floor above was too short, and they had therefore placed one side of the base on a furring strip and nailed it to the side of the floor beam, and the other side directly on a block formed by a piece of beam.

These cannot be considered in any way as isolated cases, only variations of poor construction, which seems to have been generally

PLATE V.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SNYDER ON PUBLIC SCHOOL
BUILDINGS.

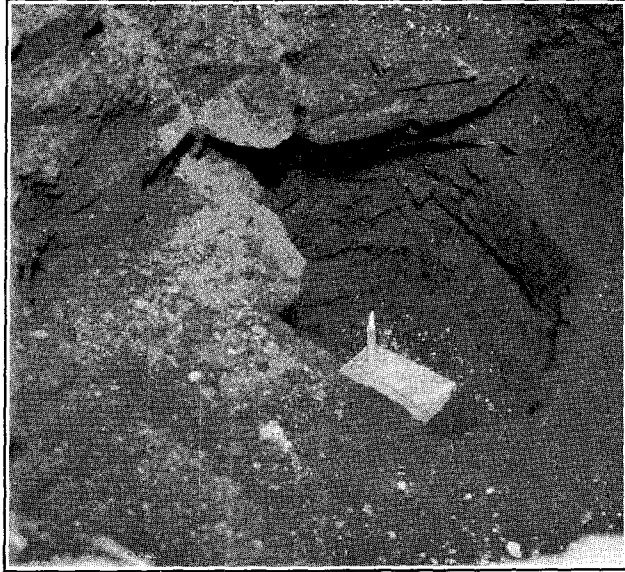


FIG. 1.

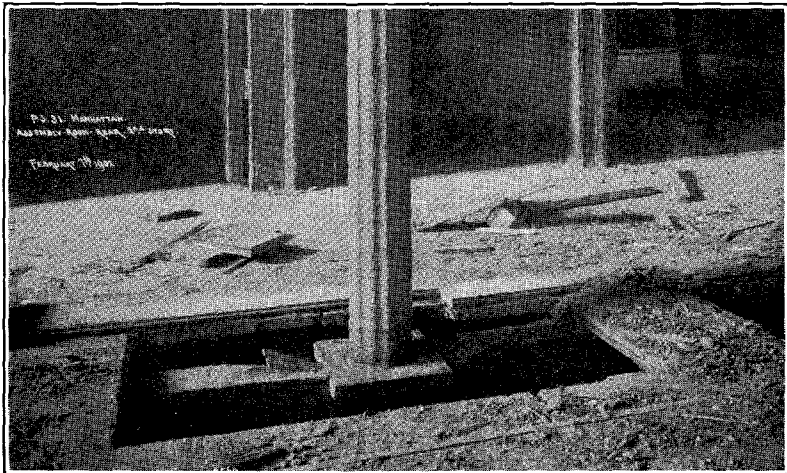


FIG. 2.

PLATE VI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SNYDER ON PUBLIC SCHOOL
BUILDINGS.

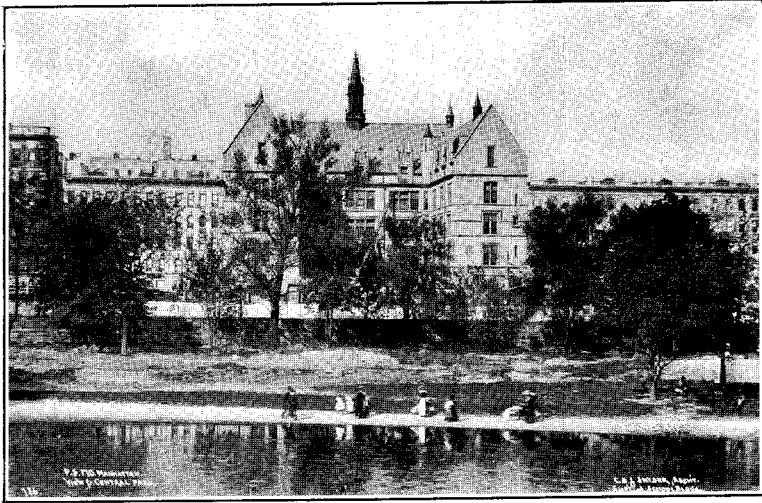


FIG. 1.—PUBLIC SCHOOL 170, MANHATTAN.

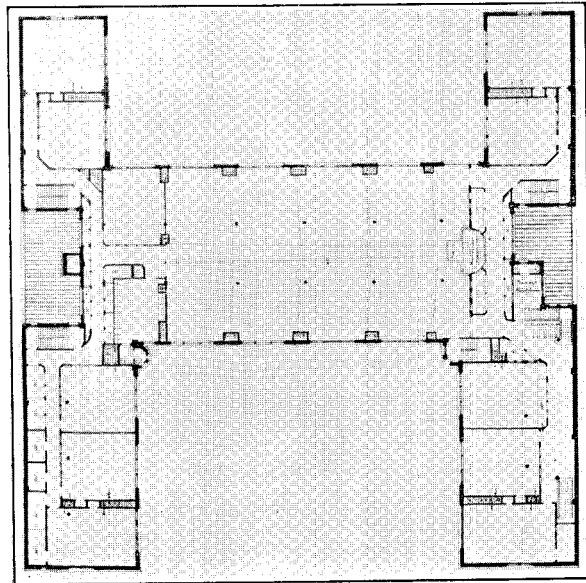


FIG. 2.—PUBLIC SCHOOL 165, MANHATTAN.

in vogue years ago, if the condition of the older public schools may be taken as any indication of the methods prevailing at that time.

In 1896, while considering plans for a new school building in an uptown district, it occurred to me that the erection of school buildings on avenue corners was unwise, not only on account of the cost, but also of the incessant noise of the up and down town traffic, it being practically impossible to obtain an avenue corner free from the noise and nuisance of passing trolley cars. I therefore designed what has become known as the "H" school building, to be erected upon a plot in the middle of the block away from the avenues, extending through from street to street, the side walls on the party lines being entirely blank, the only break being a recess in the center of the line of the plot, with stairways placed at this point. The light and air of the school building was taken almost wholly from a central court, as shown by Plate VI, Fig. 1, where the adjacent houses are built hard up to the school house walls.

Plate VI, Fig. 2, is a typical floor plan of one of these buildings, showing assembly room formed in the body of the building by means of sliding doors, which, on the other stories, are replaced by solid partitions. It will be observed that the four double stairways are placed near the central line of the building, thus affording ready access from all directions.

Some years ago the pedagogical head of the department desired these assembly rooms constructed without any columns. This was done by the use of box girders 65 ft. in length, 48 in. in length, spanning the building, and weighing about 18 tons. I do not, however, consider that the extra cost and delay was warranted by the unobstruction of view. The buildings in which these large girders were used were of the skeleton type of construction, this being made necessary through the ruling of the then Superintendent of Buildings, who maintained that we should provide for a live load of 120 lb. per square foot floor surface, there being no specific provision therefor in the building law, although the former superintendent had ruled that inasmuch as the walls of school buildings came in the same class as dwelling house walls, the floor load would be the same. Mr. Brady had previously liberally interpreted that provision of the law relating to the increase of thickness of wall due to the percent-

age of area of opening thereon. Mr. Constable ruled otherwise, with the result that had we carried out the construction necessary to meet his views, our walls in the first story would have been about 4 ft. in thickness, and the desks about 7 ft. from the light. As steel was cheap at the time, the change in construction was not an expensive experiment.

Plate VII, Fig. 1, is the new Manual Training High School in the Borough of Brooklyn, which is being fitted up in a most complete manner. The plans provide for machine and woodworking shops, forge rooms, also rooms for instruction in printing, bookbinding, sewing, domestic science, millinery, dressmaking, etc., etc. The shops are so located that if a fire should occur therein the doors connecting with the school building will close automatically, and school sessions can be continued without interference or annoyance. A partial list of equipment of the machine and other shops is here given in answer to various questions upon the subject:

Machine Shop.

- 27 Engine lathes, each $\frac{1}{2}$ h. p.
- 4 Speed lathes, each $\frac{1}{2}$ h. p.
- 18 Shapers, planers, drills, etc., for working metals, taking a total of 39 h. p. in 49 electric motors. Accommodates classes of 30 pupils at once.

Woodworking Shops.

- 10 Tools for instructors' use, getting out materials for pupils' use from rough stock.
- 31 Speed lathes for pupils' use.
- 5 Grindstones for pupils' use.
- 124 Benches, equipped with all carpenter tools.
- Total of 46 motors, giving total of 53 h. p.
- Accommodations for 5 classes of 30 pupils each.

Printing Room.

- 3 Presses, taking $1\frac{1}{2}$ h. p. in motors.

Total horse-power in 54 motors in shops is about 95 h. p.

PLATE VII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SNYDER ON PUBLIC SCHOOL
BUILDINGS.

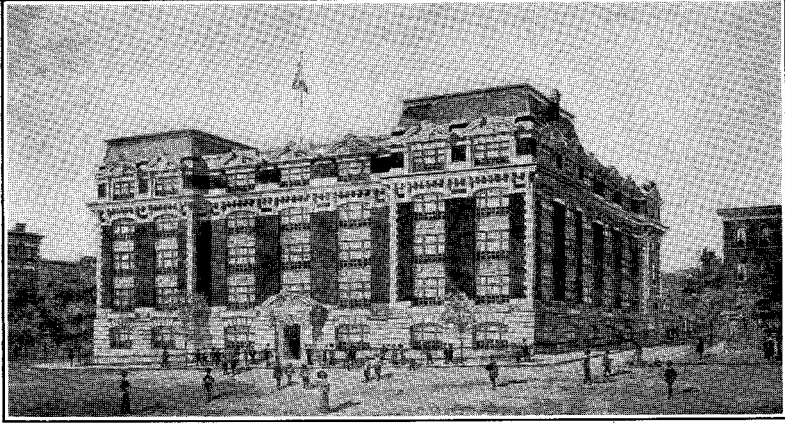


FIG. 1.—MANUAL TRAINING HIGH SCHOOL, BROOKLYN.

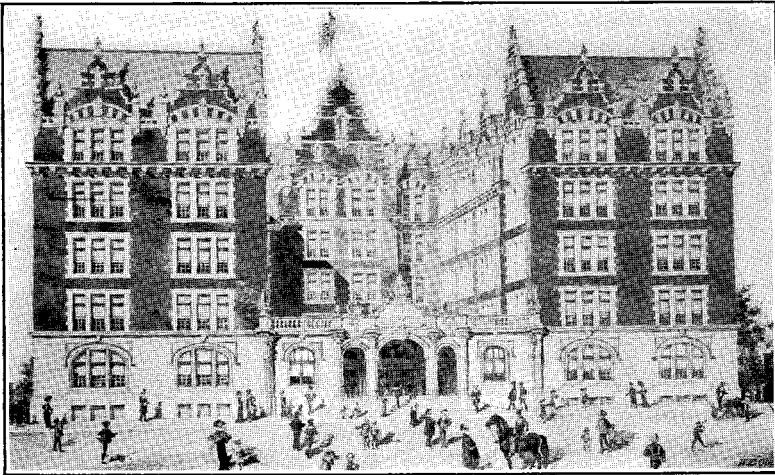


FIG. 2.—DEWITT CLINTON HIGH SCHOOL, MANHATTAN.

Blacksmith Shop.

- 1 Drill.
- 1 Exhaust blower (taking 3 motors, total of 21 h. p.).
- 1 Blast blower.
- 16 Forges with down draft.
- 32 Anvils, 30 vises, etc., accommodating over 30 pupils at once.

Mechanical Laboratory

in basement has

- 40 h-p. boiler (water tube for 125 lb. pressure).
- 30 h-p. engine, compound and direct-connected to dynamo (20 kw.).
- Surface and jet condensers.
- Gas engine with test brake.
- Electric motor with test brake.
- Water rheostat and rotary transformer, supplying 1, 2 and 3-phase alternating current from direct current.
- Also all necessary tanks, scales, etc., to make scientific engine, boiler, dynamo and motor tests.

The gymnasium, occupying about 6 000 sq. ft. of floor surface, was placed beneath the machine shops in the basement, and the equipment furnished will cost in the neighborhood of \$10 000. Contrary to the general practice, I have placed the forge room on the top floor, the gymnasium in the basement, the reason being twofold: First, better light can be obtained for the machine shop, which is used during the prior hours of the day. Second, the gymnasium is not only used in the daytime, but also afternoons and evenings, and on holidays, and should therefore be readily accessible from the street without throwing open the balance of the school premises.

Plate VII, Fig. 2, is the De Witt Clinton High School, now under construction, at Tenth Avenue and Fifty-ninth Street, which will afford accommodations for 3 800 boys, this being the largest building of the kind in the country. The main entrance is about 45 ft. in width and designed for the free use of the pupils, as I hold that when a boy has reached the age permitting him to enter high school he has also reached the age when he is entitled, as it were, to a

night-key, and should go and come through the front door. The auditorium of this building is something of a feature, since it is placed in the basement, with side entrances thereto almost directly from the grade, this being made possible through the great difference in level of Fifty-eighth and Fifty-ninth Streets, opposite these points, and that of Tenth Avenue, the front of the building, the main entrance at the front coming in at the level of the gallery. The main floor and gallery will together accommodate about 2 000, the platform being large enough to accommodate a graduating class of 100 to 150, space having been provided for an organ, while on either side of the platform provision has been made to receive two large historical pictures. Five floors of the building are occupied for class and study rooms, laboratories, lecture rooms, etc., while the upper floor beneath the roof is to be finished for a lunch room, the proposition to feed 2 000 or 3 000 boys within 30 minutes requiring very great area of floor space. The gymnasium in the basement will be 60 ft. wide by 140 ft. long, and was first to be provided with a swimming pool, which was afterwards changed to shower baths, because of the impossibility of keeping the water fresh and clean without there being a very great waste.

The Morris High School, at One Hundred and Sixty-sixth Street and Boston Post Road, The Bronx, presents an entirely different type of structure, the dimensions being 312 ft. in length by 104 ft. in depth, with an extension at the rear for the auditorium, the tower being practically 50 ft. square and 179 ft. high. The site was covered with rock 12 to 16 ft. above grade, with the exception of the easterly portion, where it dropped to 20 ft. below grade. It was therefore decided to place the heating and ventilating apparatus underneath the easterly or right-hand wing. The operation of the fans for ventilation called for special attention, since the basement, which is on a level with the street at the boiler room, did not extend under the entire length of the building. It was found necessary, in order to handle the immense amount of fresh air required per minute for the 2 500 students, to have four fans, the peculiar conditions necessitating that three should be operated by one engine, the fans being connected to the counter shaft. The speed of the fans must be regulated so that the air reaches the room at a velocity not ex-

PLATE VIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SNYDER ON PUBLIC SCHOOL
BUILDINGS.

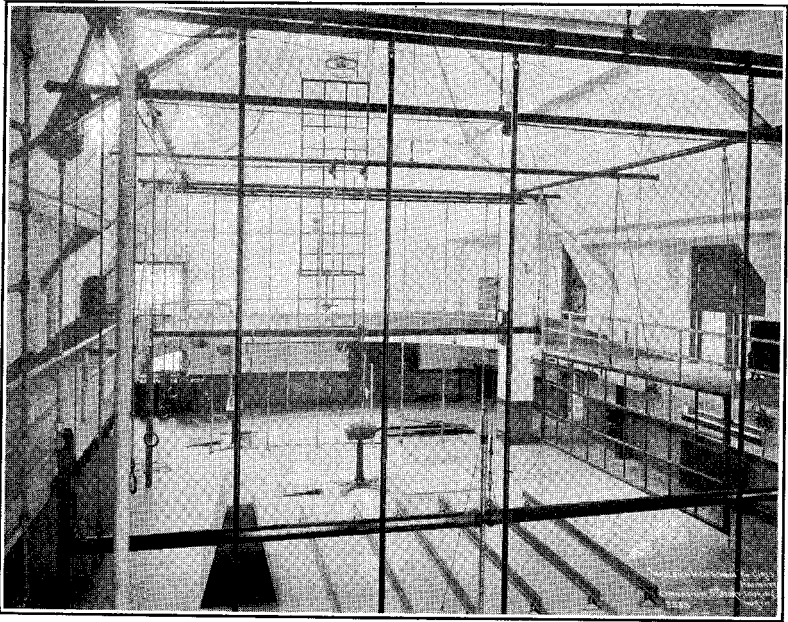


FIG. 1.—GYMNASIUM AT WADLEIGH HIGH SCHOOL.

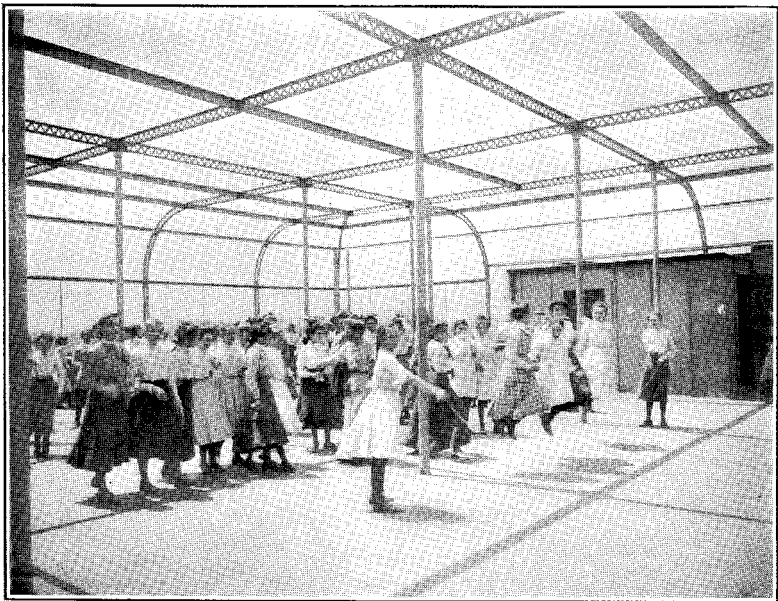
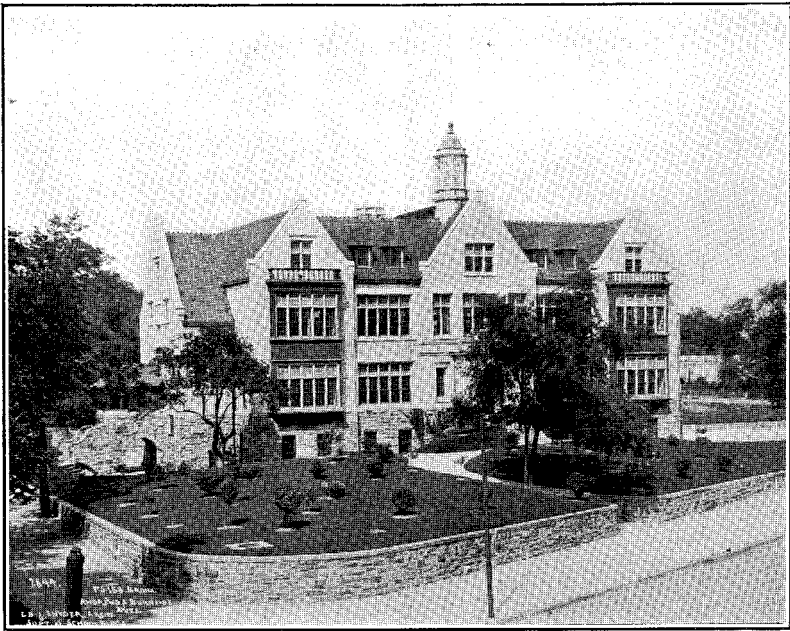


FIG. 2.—GIRLS' ROOF PLAYGROUND, PUBLIC SCHOOL 123, BROOKLYN.

PLATE IX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SNYDER ON PUBLIC SCHOOL
BUILDINGS.



PUBLIC SCHOOL 153, BOROUGH OF BRONX.

ceeding 350 ft. per minute and in volume sufficient to furnish each child with 30 cu. ft. of air per minute.

There are many features which are considered of more than passing interest in the public school buildings of New York City, some of which are the equipment of gymnasiums, with their apparatus, running tracks, etc. (Plate VIII, Fig. 1), the programme clocks in the high schools whereby the class periods are regulated automatically, the installation of electric motors, transformers, etc., the development of the heating and ventilating appliances to a point where they will work satisfactorily, the roof playgrounds (Plate VIII, Fig. 2), giving an opportunity for recreation in a space where both light and air are plentiful, instead of using dark, damp yards hemmed in by high buildings for this purpose, etc.

Not only must the buildings be designed from the engineering standpoint, but also from that of the architect, due consideration being given to the character of the surroundings. Plate IX is Public School 153 in The Bronx, which fits in well with the suburban location, while Plate X is of the tower of the new Erasmus Hall High School, Flatbush, a portion of a projected group of buildings which, when completed, will occupy a unique position among the educational buildings of this country.

DISCUSSION.

MR. NELSON P. LEWIS, President of the Society.—You have had presented to you this evening a phase of school work in this city with which some of you may have been familiar, but I do not believe there is a general appreciation of the good work done by Mr. Snyder's department. I am exceedingly glad also that Mr. Snyder prefaced his informal remarks with his written statement, which did not deal with the technical aspect of his work, but which pointed out the underlying principles of school building and emphasized somewhat the sentimental side of the educational work of this city, which must not be lost sight of. Perhaps we do not get quite enough of the sentimental side of the city's public business.

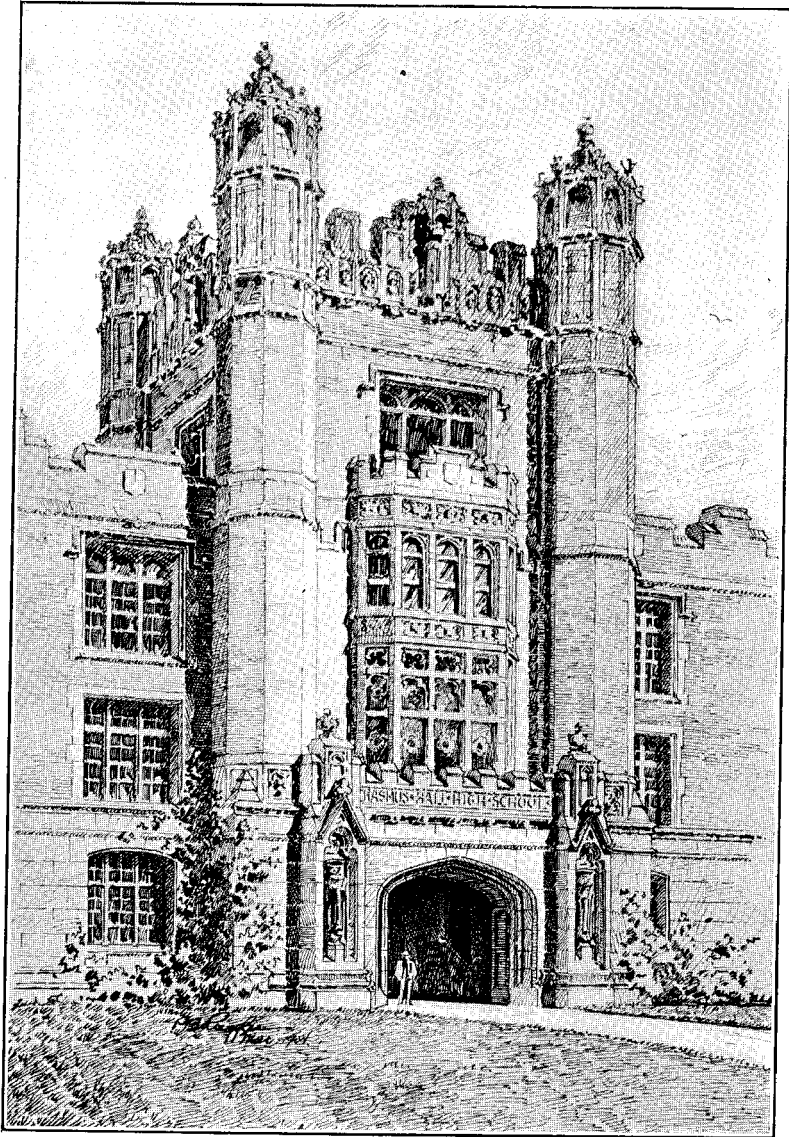
Mr. Snyder modestly refrained from enlightening us as to the cost of planning and supervising the construction of our modern school buildings, and I am going to take the liberty of asking him. You will have noticed that his plans are not typical architectural plans; they are engineering plans of architectural structures. It is interesting to go through his draughting room and see the elaboration with which these plans are prepared. I am going to ask Mr. Snyder what is the cost of designing and superintending the construction of school buildings and how it would compare with the fees that the city would be obliged to pay a competent architect to do this same work. We know the city is getting more satisfactory work, but is it saving money, or is this sort of work a luxury.

THE AUTHOR.—The actual cost of the preparation of plans and specifications, including salaries, supplies and liberal allowance for office rent, insurance, etc., is about 1½% on the value of the output. This includes all supervision, excepting the salaries of the inspectors or clerk of works. The character of the buildings is quite well known, and I will therefore only say that they are of the standard fireproof construction, all masonry being laid up in cement mortar. The cost of general construction, exclusive of heating, ventilation, plumbing, electric work and furniture, is 18 to 20 cents per cu. ft., this being exceeded only where the work is in outlying districts or there is included some peculiar feature due to site or other controlling factor.

MR. LEWIS.—May I ask how the cost per sitting compares?

THE AUTHOR.—In one of the elementary schools the cost would range somewhat less, or about \$40 per pupil, than in a number of the larger cities. The cost per pupil is, however, proportionately greater in smaller places. In high schools, however, the cost is more uniform, our high schools having been built and equipped for about

PLATE X.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SNYDER ON PUBLIC SCHOOL
BUILDINGS.



TOWER OF ERASMUS, HIGH SCHOOL.

\$223 to \$230 per pupil. The cost of the Boston High School is about \$550 per pupil; that of Springfield about \$570, and those of other cities being about the same.

MR. MAX L. BLUM, Member of the Society.—Does that include site?

THE AUTHOR.—No, the cost of the site is eliminated in all computations, as real estate values are dependent upon and vary with location, thus: A plot of ground in the Hester Street section of the Borough of Manhattan is worth \$25 000 or \$30 000 per building lot of 2 500 sq. ft., and in The Bronx and Brooklyn about \$5 000 or \$6 000.

MR. LEWIS.—May I ask how that compares with the High School of Philadelphia?

THE AUTHOR.—You know how they are said to do things down in Philadelphia; I think that building cost something over \$1 000 per pupil, but is badly planned, especially as to the stairways, of which there are only two, I think, in the main building, each about 4 ft. in width, for the use of about 800 boys, resulting in great congestion.

I would like, at this point, Mr. President, to bring up for discussion the question of foundations, mentioned earlier in our paper.

You will recall the conditions given—that of the foundations of a structure having been figured and planned for a uniform load per square foot of area upon the soil beneath, based upon the borings of the engineer, which indicated that the water table was at least 10 ft. beneath the lowest point to be reached by the footings. That the footings were not on a uniform level, a portion being down about 19 ft., at which point it is found that they will rest upon good sand, free from water, while the balance are to go down some 10 ft. lower and will rest upon sand of the same character, but now saturated with water. There arose in my mind the question as to whether or not there would be an unequal settlement of the building, due to the saturation of the material upon which the lower portion will rest.

A MEMBER.—Is there any danger of the sand moving laterally?

THE AUTHOR.—There is no danger of the sand moving laterally. The point is this: A part of the building will rest upon dry sand, and another portion, figured for the same loading and to rest upon the same material in its dry state, it is now found will rest upon the material subject to perhaps periodical saturation with water. We had a case near this same district where, through some changes in the underground flow, the water raised above the normal level, saturating the material upon which the building rested, which is a coarse, sharp sand, causing some slight settlement, and that is the reason I ask if any of you gentlemen have had any experience with the same subject.

MR. LEWIS.—You say there cannot be any lateral movement in case of deep foundations alongside or in the immediate neighborhood of your school building.

THE AUTHOR.—I don't believe in this case there could be, because it is not likely that there would be anything built which might give rise to this condition, the Park being opposite and 7-story tenements alongside.

MR. B. M. WAGNER, Member of the Society.—I have had occasion to notice a similar settlement of part of a wall, to that mentioned by the author of the paper, in a large building erected near one of our driven-well plants. We had a season of very severe pumping. It drew the water down considerably and after that we had heavy rains and the water level rose rapidly and there seemed to be a settlement near where this wall was, and certain cracks formed in the wall of the building. We shut that well off and after that pasted strips of paper over the cracks and found no more movement. This is something in the line that Mr. Snyder speaks of. We had the differences in the water level, and settling of sand and consequent cracks at points of greatest difference in levels.

MR. A. S. TUTTLE, Member of the Society.—How about sand movement? Did not the sand have an outlet in the well?

MR. WAGNER.—No, I think not; if there was an outlet the same settlement should have taken place around the other wells. As a matter of fact, no such settlement shows at any other well. One of the wells was in the space occupied by the building and was left in place.

MR. LEWIS.—Mr. Snyder shows one or two cases of important columns resting upon small strips of wood or shims. I remember a similar case in the Borough Hall, Brooklyn, a year or two ago, where columns carried through a large room to the story above supported the floor of the Aldermanic Chamber. One of these columns was supported on a few bricks corbled out in three courses, and they were very ordinary building bricks; in another case one rested on a wooden beam and was shimmed up with shingles. Yet this had stood for many years.

MR. WAGNER.—Where the column was over the well. If that had stood for some 40 years without settlement, why does it settle at that particular time?

THE AUTHOR.—That is what puzzled us. There was no building being carried on in the neighborhood. Apparently it all of a sudden began to sink and thus attracted attention.

The column had been blocked up on top with cast-iron blocking apparently from time to time, but no recent appreciable movement was shown.

MR. LEWIS.—In building the new Erasmus Hall High School,

will it be necessary to remove the large trees in front of the old building?

THE AUTHOR.—We preserve quite a large number. In fact, we preserve the best of them. I think the trees, with one or two exceptions, are dead at the top. Many have been broken off by the wind and show indications that in 10 years they would have to be taken down. In order to carry out the new scheme, a piece of property on the westerly side will have to be acquired so as to make the front uniform in width with that of Bedford Avenue. The idea is to plant trees as far as possible, almost immediately.

MR. TUTTLE.—To prepare and carry out plans for such elaborate structures as the school buildings, without incurring an allowance to the contractor for "extra work," indicates an unusual completeness of plan and familiarity with the conditions to be met. I should like to ask Mr. Snyder if the foundation work is bid for by prices for the various items of which it is made up, or if a lump sum is named for the building complete?

THE AUTHOR.—The prices are given as a lump sum.

MR. W. F. JONES, Member of the Society.—In regard to the compression of the foundation, I should think that such a thing was possible. The particles of dry sand, when under pressure, will arrange themselves in certain form. Of course, all the particles of sand are not of the same size; there are small and large. When that sand becomes saturated with water, of course there is more movement along the smaller particles and a rearrangement is liable to take place which might cause a slight settlement.

MR. H. R. ASSERSON, Member of the Society.—I do not agree with the gentlemen about the foundations. I think we can build upon quicksand or saturated sand, providing it is confined either by sheeting or by natural earth conditions. I think Mr. Snyder's building would be perfectly safe unless some work was performed in the near vicinity, say, by excavation, which would result in the wet sand running to a new location. I know in Brooklyn we build below the water table. I had occasion to see the water table rise after severe rainfalls, where foundations extend into and below it, and have noticed after the heavy rainfalls of last year that this water table rose some 20 in. and again subsided without damage to said foundations. Now, if you build safely under conditions of this kind, why is Mr. Snyder's school not perfectly safe? We all know you can support considerable weight on water confined, which will be a permanent support, providing nothing is done to allow the water to escape. I understand that the condition explained by Mr. Snyder exists at only one or two points and that the movement of sand is confined by adjacent good earth, occasionally wetted, practically by water rising and taken up in

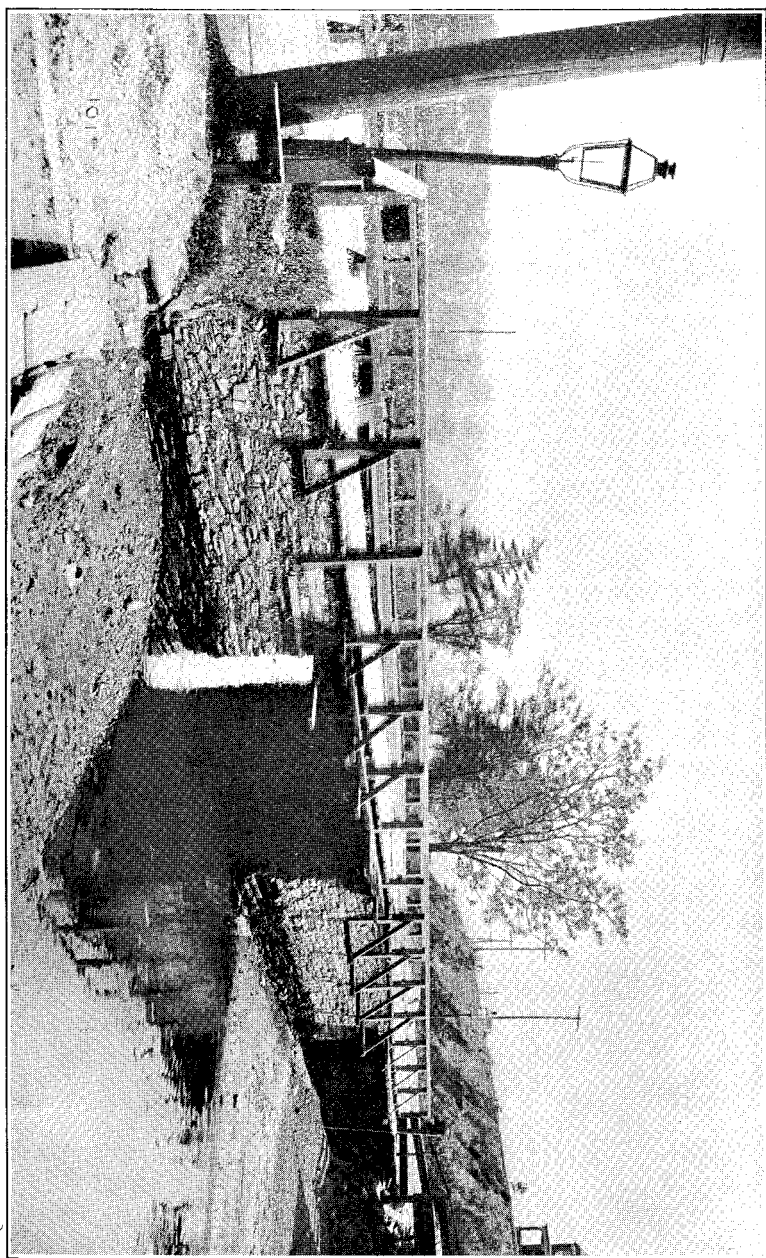
the earth by absorption. I cannot conceive how any movement of material could happen which would endanger the building under the conditions.

MR. JOHNES.—The gentleman misunderstood me, I think. I did not say that wet sand might not be confined to a good foundation. I simply say that when the foundation is built on dry sand and when the sand afterwards becomes wet, I think a rearrangement takes place.

THE AUTHOR.—Here is a foundation which will never be saturated and never can be saturated, and the other part is now and probably will be every time that we have a winter of the character of this year, and it is exposed to moisture and then to drying up, while the upper part, the 19 ft., will never be otherwise than the dry material. We frequently build on wet sand and nothing else. It is all right, wet or dry, as long as your units and conditions are always the same.

MR. WISNER MARTIN (by letter).—Considering the necessity for guarding against even the slightest uneven settlement of the foundations of the building, I believe the author would not be justified in ignoring the, at times, wet condition of the sand under the column foundation which he referred to. My experience teaches me that when the compact dry sand becomes saturated with water, the mass has a tendency to flow and become more compressible, the water in the interstices acting as a lubricant between the grains of sand and allowing it to move horizontally. This movement, under the conditions described, would not extend over but a small area. Under the circumstances I would reduce the weight per square foot under this column from four to three tons, or one-quarter, at least.

PLATE XI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.



KINGS BRIDGE.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

Paper No. 10.

HARLEM RIVER BRIDGES.

BY MARTIN GAY, MEMBER OF THE SOCIETY.

PRESENTED MAY 27TH, 1904.

Mr. President and Gentlemen of the Society:

I shall have the pleasure of showing you to-night some photographs of the municipal bridges over the Harlem River. But I first wish to express my thanks to Mr. George E. Jackson, of the Department of Bridges, and to Mr. J. E. Palmer, Jr., our official photographer, to whose skill and good judgment we are indebted for most all of these pictures, and particularly to Mr. Jackson, who has tabulated the statistics of the bridges of the department.

Kings Bridge (Plate XI).—The settlers of Manhattan Island felt the need at an early day of a better means of communication with the main land than was afforded by boats, and within seventy years of the building of the first permanent dwelling-house at the Bowling Green, a franchise was granted, in 1693, to Fredryck Philipse to build a bridge over Spuyten Duyvil Creek on the old post road, now Broadway, which was then and remained for many years afterward the main road leading from New York up the Hudson Valley and eastward to the Sound and the New England colonies. (Plate XII.)

The bridge erected by Fredryck Philipse is said to have been situated a little to the east of the present bridge, but probably did not differ from it materially in dimensions or construction.

The terms of the franchise allowed the owner of the bridge to collect tolls from all travelers except the King's forces, and it was

to be called the Kings Bridge, as it is called to this day. It remained in possession of the Philipse family until the Revolution, when, with much other property of the family, it was confiscated by the patriot government.

Broadway Bridge (Plate XIII).—The old road, still the main artery of travel to the north through Manhattan Island, has been widened and straightened and a new bridge built over Spuyten Duyvil Creek, Broadway Bridge, built under Chapter 399, Laws of 1896, and Chapter 86, Laws of 1897, was completed in the year 1900, and it may be looked at as an example of modern city bridge building as compared with its neighbor, which was built 200 years earlier. The Kings Bridge was 24 ft. wide, of timber, probably hewn from the trees of the neighboring forests, with rough stone abutments laid without mortar. The cost was perhaps a few hundred dollars. The Broadway Bridge consists of steel plate girders, with brick jack arches between 12-in. I-floor-beams, carrying the asphalt pavement. The granite abutments are laid with Portland-cement mortar. It is 100 ft. wide and cost \$79 921.63.

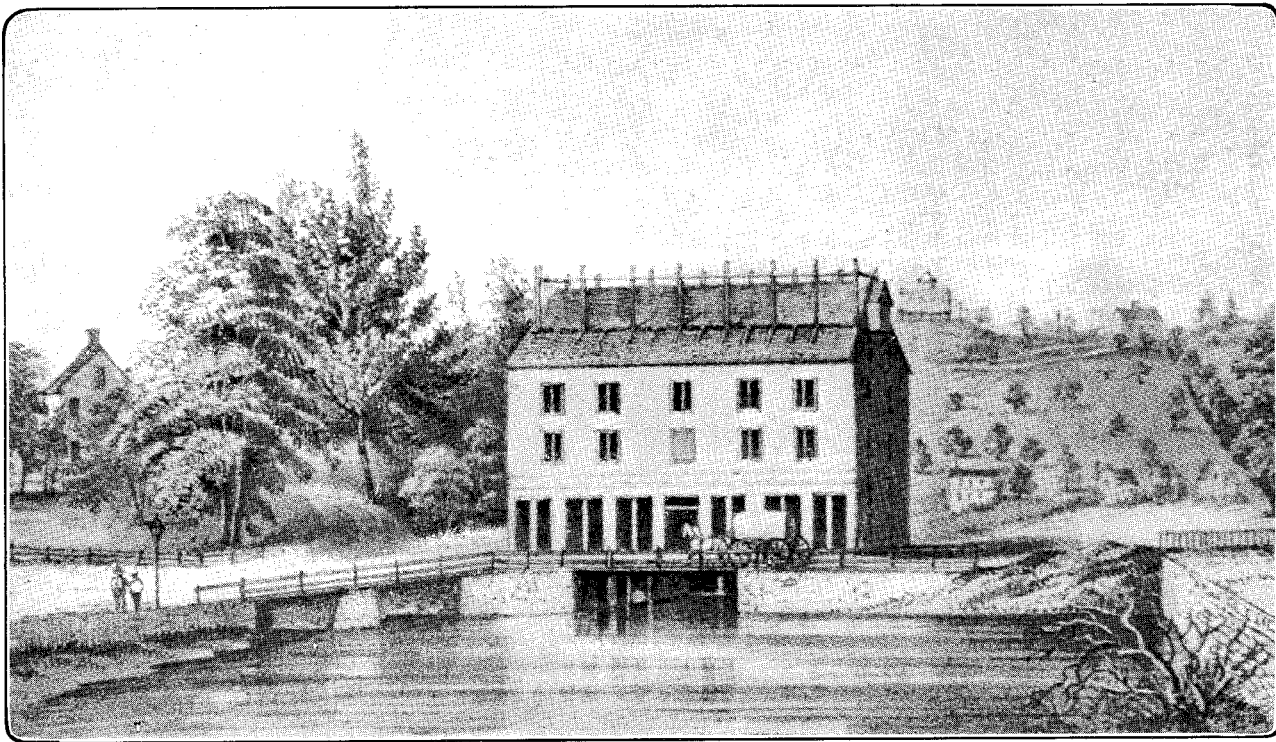
Farmers Bridge (Plate XIV).—Going back again in time, but keeping on down Spuyten Duyvil Creek to its junction with the Harlem River, we come to the Farmers Bridge.

This was built in 1759 by the farmers of Westchester County, who, after nearly seventy years of toll-paying at Kings Bridge, became exasperated at the exactions of the Philipse family and raised by subscription a sufficient fund to build a free public bridge.

It is still called Farmers Bridge, and you see it now in probably very much the same condition as it was 150 years ago.

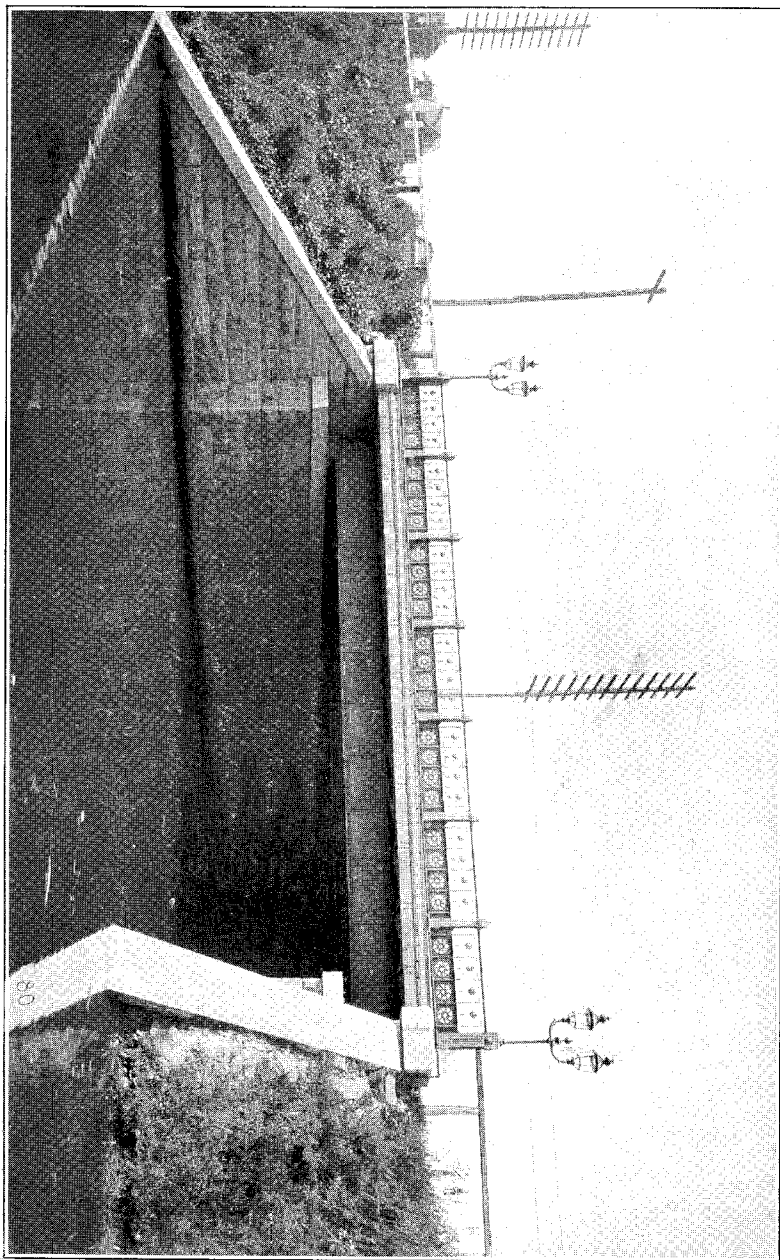
Ship Canal Bridge (Plate XV, Fig. 1).—When the Federal Government cut a canal across the north end of Manhattan Island it became necessary to build a drawbridge over it on the line of Broadway. This was authorized by acts of Legislature, Chapter 232, Laws of 1892, and Chapter 48, Laws of 1894. It is called the Ship Canal Bridge, and it was completed and opened to travel January 1st, 1895, at a cost of \$476 863.94. The draw span is 270 ft. long and is approached from either end by a span of 100 ft. The roadway is 33½ ft. wide and the two sidewalks are 7½ ft. wide each.

Like all drawbridges on the Harlem River, this is a rim-bearing



KINGS BRIDGE AND MACOMBS MILL.

PLATE XIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.



BROADWAY BRIDGE.

PLATE XIV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.



FARMERS BRIDGE.

PLATE XV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.

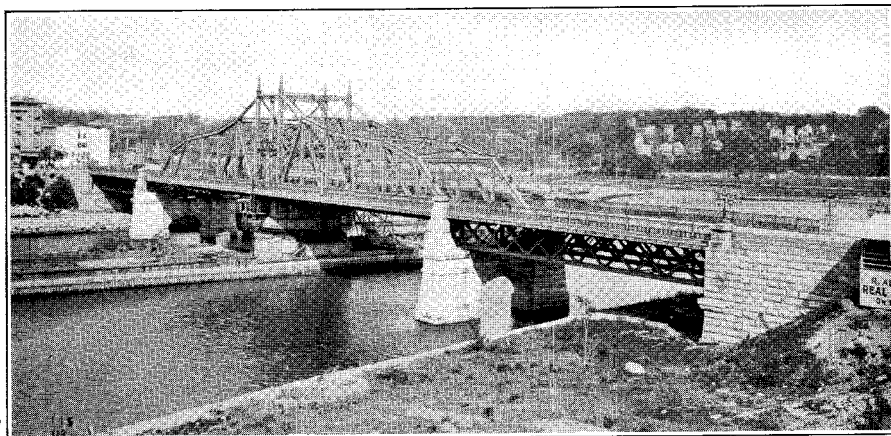


FIG. 1.—SHIP CANAL BRIDGE.

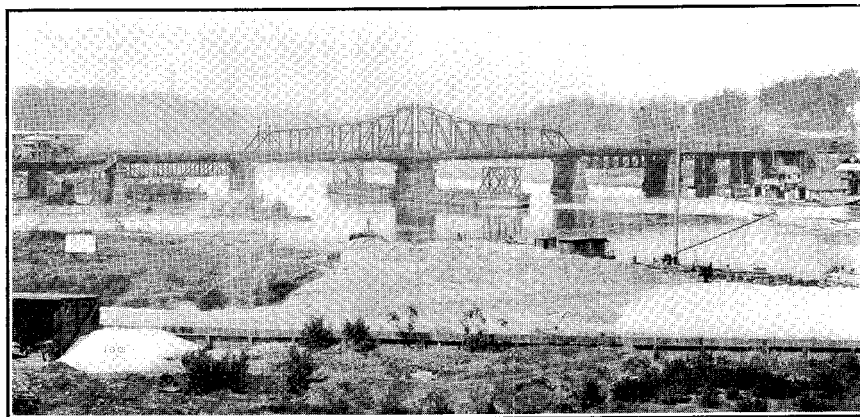


FIG. 2.—NEW YORK AND PUTNAM BRIDGE.

bridge, as distinguished from center-bearing bridges; that is, all the weight of the structure is distributed to a circular drum which moves upon coned rollers, which, in turn, move upon a track resting near the edge of the masonry of the round-pivot pier. No weight whatever is carried by the center pin, which is, in fact, not a pin, but a heavy casting, fixed in its position, around which the moving parts of the turntable revolve.

The Rapid Transit Railroad, which, after leaving the tunnel under Fort George, crosses the Dyckman meadows on an elevated structure, will cross this bridge overhead.

The new location of the New York Central tracks will pass under the north fixed span, and the Metropolitan Street Railway will in the near future cross the bridge with its tracks. All these improvements will necessitate a practical rebuilding of the bridge, and it has been proposed, instead of trying to adapt the old structure to new uses, to move the three spans bodily to another location, and to build a new structure in their place.

University Heights Bridge.—This has not yet been decided upon, but if the project is carried out, the old spans from Broadway will be taken down stream and become part of University Heights Bridge, which will extend from Ninth Avenue and Two Hundred and Seventh Street in Manhattan to One Hundred and Eighty-fourth Street in the Bronx. Work on the University Heights Bridge has already begun, a contract having been let in October, 1903, for the dredging, the fender and the pivot pier. The caisson for the foundation of the pier is now being sunk and is expected to go down about 90 ft. below high water before it reaches its stopping place on rock.

The caisson is octagonal in plan, and is solid, although some economy might have been gained by the annular form.

One reason for this apparent extravagance is that if at any time it should be desirable to build a center-bearing draw on the pier, there will be a solid masonry foundation under the center casting to carry the enormous weight which will rest on it.

Washington Bridge (Plate XVI).—In 1869 the Legislature passed an act authorizing the survey of the southern part of Westchester County and the location of bridges and tunnels connecting it with

Manhattan Island. Taking advantage of this law, the late Andrew H. Green urged the location and construction of a bridge at or near Highbridge, but although the necessity of a bridge at this point was plainly seen, nothing was done toward building it till, mainly, if not entirely, through Mr. Green's efforts, an act of Legislature was passed June 11th, 1885, providing for the construction of such a bridge by a special commission.

This is called Washington Bridge, and is one of the notable bridges of the world.

It is built on the line of One Hundred and Eighty-first Street prolonged and extends from Amsterdam Avenue in Manhattan to Aqueduct Avenue in the Bronx, a distance of 2 377 ft. The roadway is 50 ft. wide and the sidewalks 15 ft. wide each.

The two main arch spans are 508 ft. 9½ in. between end pins, and the height in the clear above high water is 133½ ft. There are six steel solid-web ribs of the two-hinged type in each main arch span, upon which rest the posts which carry the roadway. The approaches are of granite masonry of substantial and quite elaborate construction.

The bridge was opened to travel in December, 1888, and finally completed and accepted in March, 1889. The cost was \$2 851 684.58.

A strip of land 150 ft. wide on each side of the bridge was bought on both sides of the river in connection with the bridge for park purposes, and was improved by the commission and is now maintained by the Department of Parks. The total cost of the bridge and park was:

Cost of bridge under contract.....	\$2 648 784.55
Engineering, office expenses, etc.....	202 900.00
Improving parks, etc.....	493 435.62
Land for bridge and parks.....	37 751.78
	<hr/>
	\$3 382 871.95

The first Chief Engineer appointed by the commission was Mr. Wm. J. McAlpine. He was succeeded by Mr. W. R. Hutton, who remained in that position until the completion of the work.

New York and Putnam Bridge (Plate XV, Fig. 2).—In the

PLATE XVI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK,
GAY ON HARLEM RIVER BRIDGES.



WASHINGTON BRIDGE.

neighborhood of One Hundred and Fifty-eighth Street the New York and Putnam Railroad Bridge crosses the Harlem River. The franchise under which it was built provided that sidewalks should be built and maintained for the use of the public by the railroad company. To one of these sidewalks the City in 1892 built approaches. They were built by permission of the railroad company on its land and were intended to be temporary structures only. It is hoped that in the near future something more permanent and more in keeping with the rapidly improving surroundings may be substituted for them.

Macombs Dam Bridge.—In the year 1813 Robert Macomb petitioned the Legislature for the right to build a dam from Bussing's Point in the Ninth Ward of New York City to Devoe's Point in the Town of Westchester. This right was granted by Chapter 148, Laws of 1813, which provided that a space should be left in the dam for water to pass freely, controlled by flood-gates, that the salt meadows between the dam and Kingsbridge should not be flooded, that a lock should be built to permit the passage of boats and vessels with a proper person to operate it, and that the assent of the Mayor, Aldermen and Commonalty should first be obtained.

This consent was obtained from the Common Council January 10th, 1814, and shortly afterward Macomb's Dam was built at what is now One Hundred and Fifty-fifth Street, making the Harlem River between that point and Kingsbridge a mill pond for the use of his mill at that place. In the proceedings of the Common Council the proposed structure is variously spoken of as a dam and as a bridge, and Macomb, in a memorial to that body, says a bridge will be a great public convenience, that he will levy a moderate toll and will donate to charity one-half of all toll collected. Probably it was at first used for both purposes, but later in the century, between 1830 and 1840, Macomb's Dam ceased to be used as a dam and was transformed into a bridge. A picturesque account of this transformation is that the dam was forcibly seized by a band of angry farmers, who tore it down and reopened the stream to navigation. Another account is that openings were made in the dam from time to time by riparian owners whose lands were flooded by it, and the openings spanned by short bridges to allow people to cross. Perhaps there is

truth in both stories, for the fact is evident from the oil painting now in possession of Mr. Gabe Case and corroborated by a print in Valentine's Manual for 1860, that shortly before that time the bridge was composed of a series of rough stone piers connected by short wooden spans, with what appears like a lift bridge near the Bronx shore (Plate XVII). An act of Legislature, Chapter 291, Laws of 1858, conferred authority on a commission to remove the dam and build a new bridge, the cost of which was to be shared by the Counties of New York and Westchester. This act was amended in 1859 and in 1860 as to time of completion and cost. The last amendment assessing \$10 000 of the cost on Westchester County and \$40 000 on New York.

According to the legend on the sandstone tablet built into the center pier, it was called Central Bridge. It was erected in 1860. The Commissioners were Lewis G. Morris, Charles Bathgate, Richard F. Carman and William Jas. Stewart. E. H. Tracey was the engineer. John Ross and D. L. Harris were the builders. (Plate XVIII.)

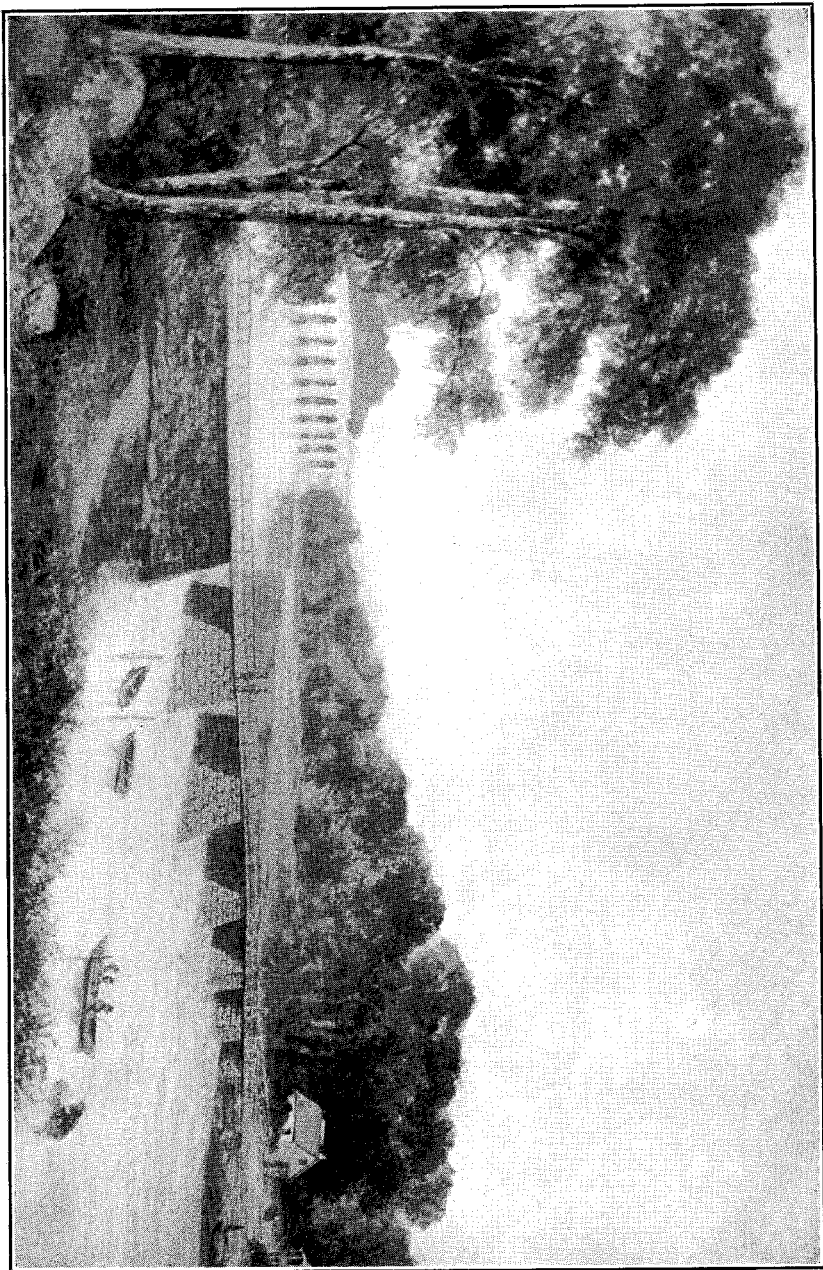
It was officially known as Central Bridge, though in common speech the old name of Macombs Dam still clung to it. The structure was of wood. In the center of the draw span there was a square tower from which its ends were supported by iron rods. The approach spans were Howe trusses. This was rebuilt and repaired at various times. At one time, probably in 1877, the square tower was replaced by A-frames, and in 1883 the Howe trusses, which had been supported on trestles, were replaced with iron trusses. The draw was rebuilt again in 1890. This span was 210 ft. long, the roadway 18 ft. wide and the two sidewalks 4 ft. wide each. The approach spans were 180 ft. long each.

In 1892 the old bridge was torn down and replaced by the present structure, for which Mr. A. P. Boller was the Consulting Engineer. It was completed and opened to the public May 1st, 1895, at a cost of \$1 359 693.55.

The draw spans the river from bulkhead line to bulkhead line, a distance of 400 ft., the roadway is 40 ft. wide and each sidewalk is 9 ft. 9 in. wide.

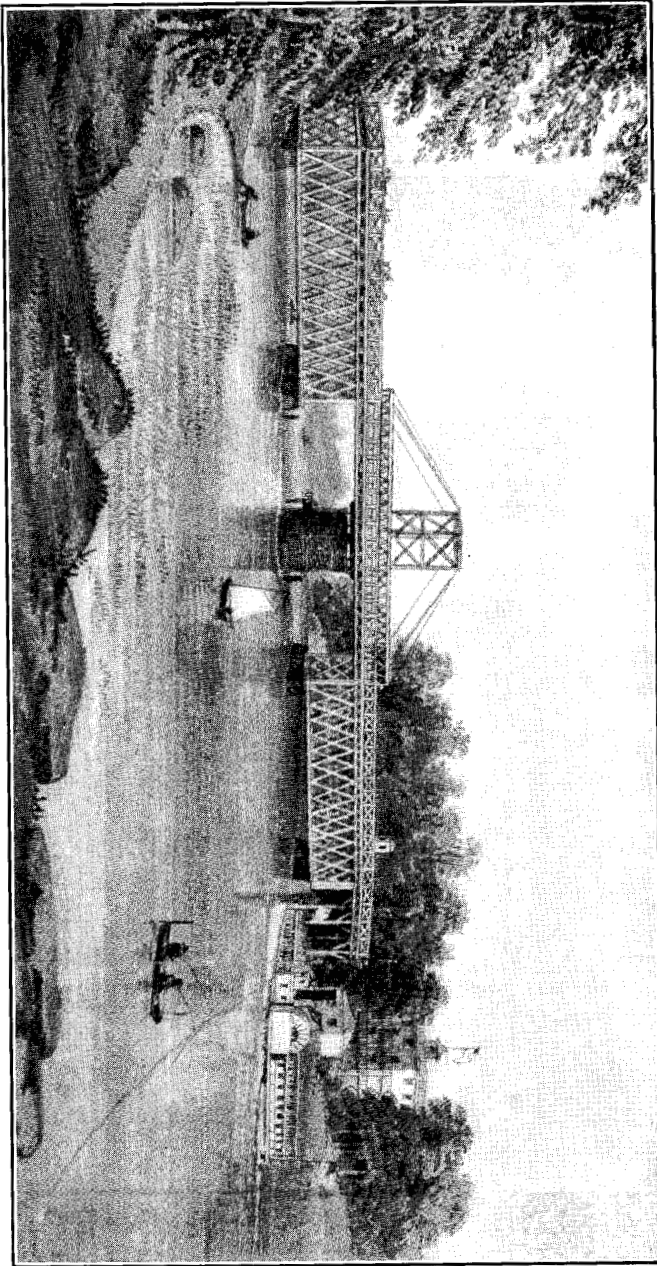
The opportunity for architectural effect offered at this bridge

PLATE XVII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.



MACOMBS DAM BRIDGE PRIOR TO 1858.

PLATE XVIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.



MACOMBS DAM ON CENTRAL BRIDGE.

PLATE XIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.

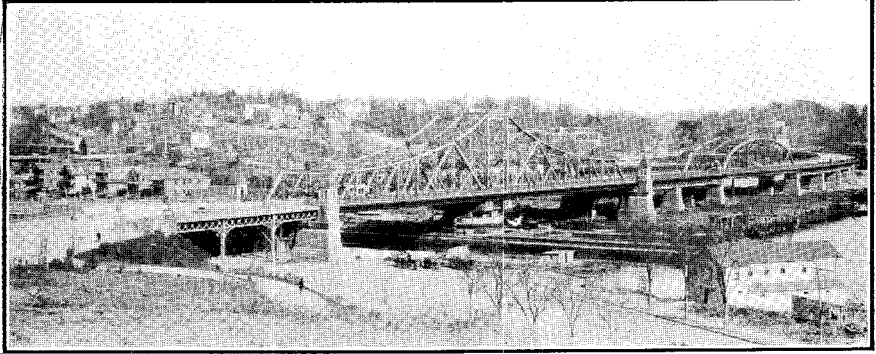


FIG. 1.—MACOMBS DAM BRIDGE.

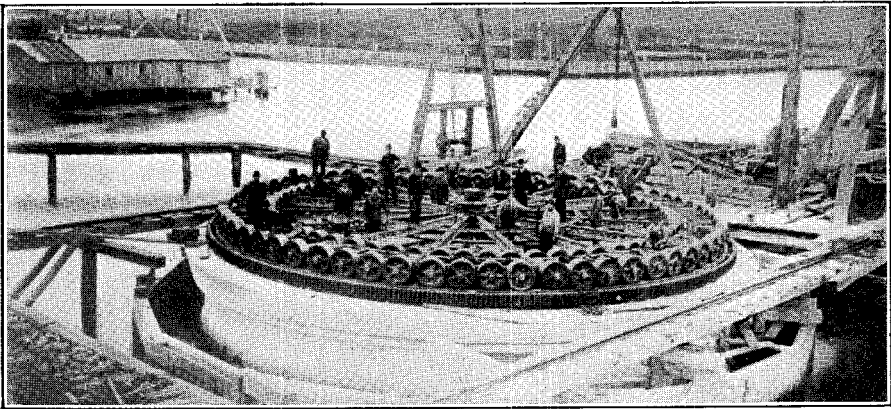


FIG. 2.—DOUBLE DRUM OF MACOMBS DAM BRIDGE.

was taken advantage of by Mr. Boller, as can be seen in the fine lines of the masonry and the graceful sweep of the upper chord of the draw span (Plate XIX, Fig. 1). The red tile roofs of the four little houses are spots of warm color which relieve the severe simplicity of the painting. To accommodate travel while the new bridge was building, the old draw was picked up on scows and moved to One Hundred and Fifty-sixth Street, where a pier had been prepared for it and approaches built. In that position it did service for three years longer, until the new bridge was completed. Central or Macombs Dam Bridge was built by the Department of Public Parks by authority of Acts of Legislature, Chapter 207, Laws of 1890; Chapter 13, Laws of 1892, and Chapter 319, Laws of 1893. The meaningless name of Central Bridge was officially abandoned and the original name of Macombs Dam adopted by resolution of the Board of Aldermen, November 11th, 1902.

One Hundred and Forty-fifth Street Bridge (Plate XX, Fig. 1).—The contract for the Lenox Avenue or One Hundred and Forty-fifth Street Bridge was let in December, 1897, but work was not begun till the latter part of 1900. During that time additional legislation had been obtained authorizing the expenditure of \$500 000 in addition to the \$1 250 000 already allowed, permitting a revision of the contract, and allowing the bridge to be increased in width and decreased in length from 400 to 300 ft. The work is not yet completed, having been delayed by the construction of the Rapid Transit tunnel, which crosses Harlem River under the south end of the fender pier. There will be two roadways, each 27 ft. wide, and two sidewalks, each 9 ft. wide.

Electricity will be used for both lighting and power. Legislative authority for its construction was granted by Chapter 986, Laws of 1895, and Chapter 719, Laws of 1900.

Madison Avenue Bridge (Plate XX, Fig. 2).—The Madison Avenue Bridge, crossing the river at One Hundred and Thirty-eighth Street, was completed in 1884 by the Department of Public Parks at a cost of \$498 880.87.

Like all drawbridges on the Harlem except Macombs Dam, there is a pivot pier and two rest piers in the stream. The draw is 300 ft. long, the roadway 21 ft. 4 in. wide—sufficient for two lines of

vehicles only—and the sidewalks are 5 ft. 6 in. wide. The approaches are steep, narrow and crooked, and the whole structure, though only twenty years old and still in good condition and serviceable, has been outgrown by the demands of travel. A new bridge of ample dimensions and modern equipment will replace the old one at an early date.

Third Avenue Bridge.—For many years after Kings Bridge was built all travel to lower Westchester County went over it and Farmers Bridge, when a much shorter route would have been up the Bowery and Third Avenue and across the lower end of the river, but it was not until 1774 that Colonel Lewis Morris applied for and obtained permission to build a bridge in connection with a proposed road through Harlem and Morrisania to Eastchester. It does not appear that this permission from the Common Council was made use of, possibly because the terms of the grant forbade the collection of tolls, but afterward, March 31st, 1790, Lewis Morris was authorized by the Legislature to build a bridge between Harlem and Morrisania, not less than 30 ft. wide, "and between the center arches thereof shall be an opening not less than 25 ft., over which shall be a draw not less than 12 ft. for the free passage of vessels with fixed standing masts," and to collect certain specified tolls for the term of sixty years.

This act was made operative by the Common Council December 9th, 1793, resolving to "demise as much of the soil from high to low water mark in the said river as may be necessary for the purpose of the said bridge, * * * reserving a rent of one pepper corn per annum."

Colonel Morris does not appear to have taken advantage of this privilege, for the legislative act of March 24th, 1795, recites that Lewis Morris, having assigned his rights under Chapter 31 of the Eighteenth Session to John B. Coles, Coles is granted the right to build a dam for the use of mills, which shall also serve as foundations of a bridge.

He must provide a lock 8 ft. wide and 2 ft. deep and furnish an attendant.

He was placed under bonds of £4000 to build a bridge not less than 24 ft. wide within four years of the passage of the act, and

PLATE XX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.

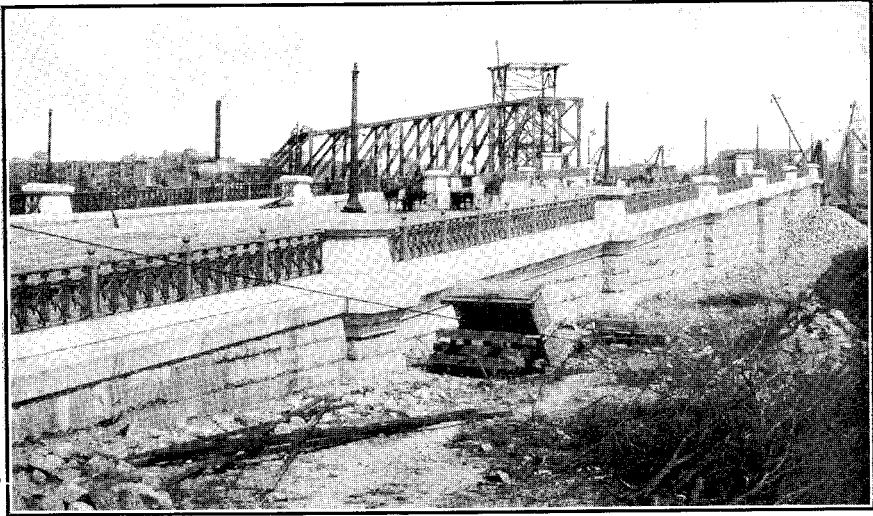


FIG. 1.—145TH STREET BRIDGE.

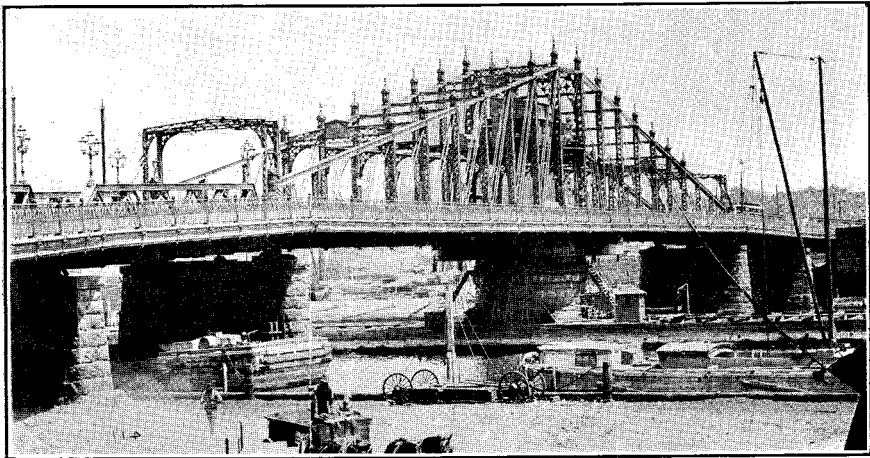
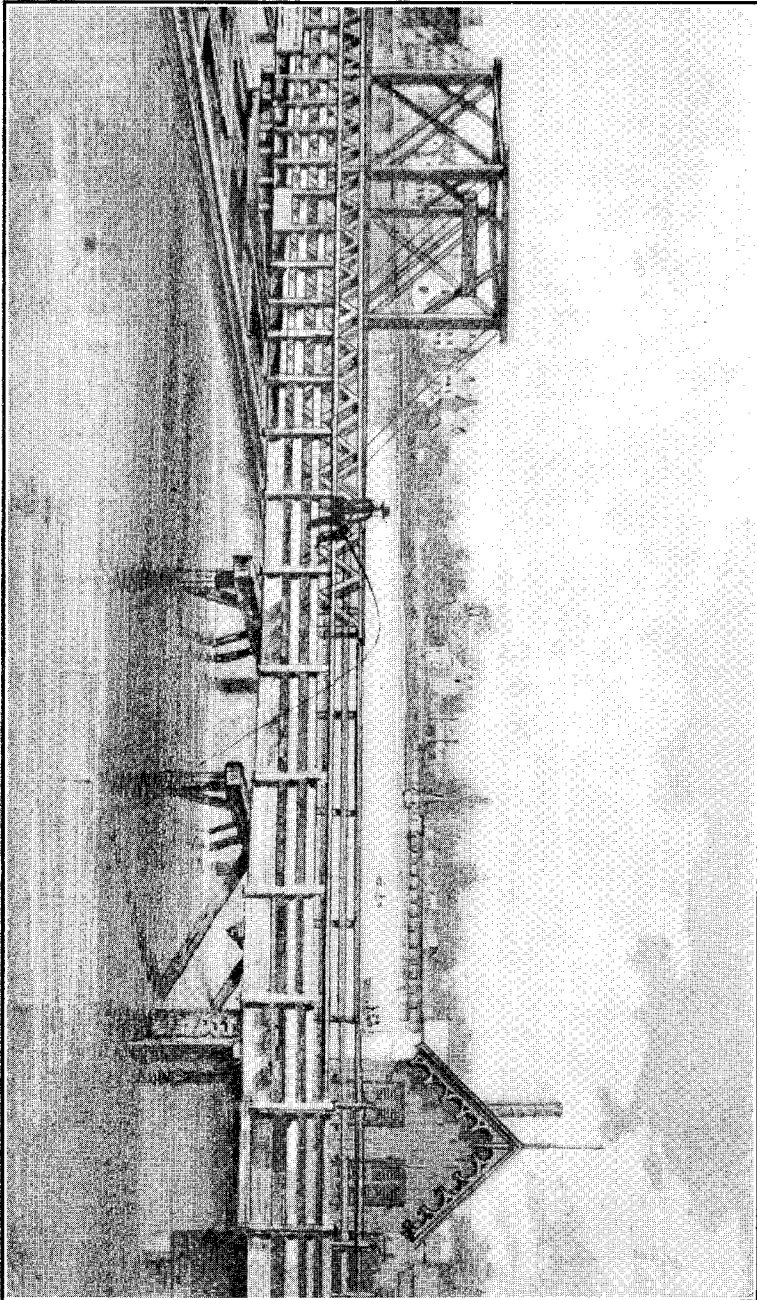


FIG. 2.—MADISON AVENUE BRIDGE.

PLATE XXI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK,
GAY ON HARLEM RIVER BRIDGES.



COLLIER BRIDGE.

after sixty years it should become the property of the State. He was allowed to collect the same tolls granted to Morris and could retain the dam forever if it was kept in repair and a proper attendant provided.

There is evidence that Coles took advantage of the privilege granted him as to the bridge (Plate XXI) in traditions concerning it and in the very good picture presented in Valentine's Manual, but he appears to have neglected the apparently valuable right to dam the Harlem River.

By act of Legislature, Chapter 774, Laws of 1857, the Coles Bridge became the property of the people of the State of New York on April 1st, 1858, and was made free to the public, and it was repaired and remained in use until the famous "Harlem Bridge" (Plate XXII, Fig. 1) was opened to the public on October 16th, 1867.

This bridge was authorized by the same act of Legislature, and under it the Mayor and Street Commissioner of New York and the County Judge and Chairman of the Board of Supervisors of Westchester County were appointed a Commission for its construction. The late William J. McAlpine was the first Chief Engineer, who was succeeded by Erastus W. Smith.

This was a remarkable undertaking for its day. The foundations of the piers were cast-iron cylinders 6 ft. in diameter, sunk by the pneumatic process. This was among the first applications of compressed air to bridge building in this country. The bridge was of iron and its prominent feature is the arched upper chords of the spans. Its total length was 468 ft., draw span 234 ft., and fixed spans 117 ft. each. The draw openings were 80 ft. wide, and it was 13 ft. above the water. The River and Harbor Acts of September 19th, 1890; August 17th, 1894, and June 3d, 1896, obliged the City to provide a clear headroom of 24 ft. above high water of spring tides at all Harlem River bridges, and in compliance with these acts the old "Harlem Bridge" was removed in 1894. It was closed to travel June 20th, 1894, and from that time to August 1st, 1898, when the new bridge was finished, travel passed over a temporary bridge, built a short distance east of the permanent one.

The present bridge (Plate XXII, Fig. 2) was built under authority of Chapter 413, Laws of 1892; Chapter 716, Laws of 1896, and

Chapter 660, Laws of 1897, at a cost of \$1 768 830.22. The draw span is 300 ft. long. There are three roadways, each 17 ft. wide, of which the center road is used exclusively by trolley cars. On the Manhattan side there are two approaches, one from One Hundred and Thirtieth Street and Lexington Avenue, the other from One Hundred and Twenty-eighth Street and Third Avenue. On the Bronx side the approach ends at One Hundred and Thirty-fifth Street, although Third Avenue was widened and repaved as far north as One Hundred and Thirty-eighth Street, making an ample entrance to the bridge.

The structure was designed and its construction supervised by the late Mr. T. C. Clarke as Consulting Engineer for the Department of Public Works, and after 1897 for the Department of Bridges.

Willis Avenue Bridge (Plate XXIII).—The last bridge over the Harlem River before its junction with the East River is the Willis Avenue Bridge. It was built under authority of Chapter 147, Laws of 1894; Chapter 664, Laws of 1897, and Chapter 607, Laws of 1901. Mr. T. C. Clarke was Consulting Engineer for the Department of Public Works and later for its successor, the Department of Bridges. The cost was \$1 499 687.06. The bridge extends from One Hundred and Twenty-fifth Street and First Avenue in Manhattan to One Hundred and Thirty-fourth Street and Willis Avenue in the Bronx, crossing the freight yards of the New York, New Haven and Hartford Railroad with a series of plate girder spans on granite piers. The draw span is 300 ft. long, with roadway 42 ft. wide and sidewalks 9 ft. wide.

The bridge was completed and opened to travel August 22d, 1901.

An additional approach is about to be built from the Southern Boulevard, which in general design and construction will be in keeping with the rest of the bridge.

PLATE XXII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.

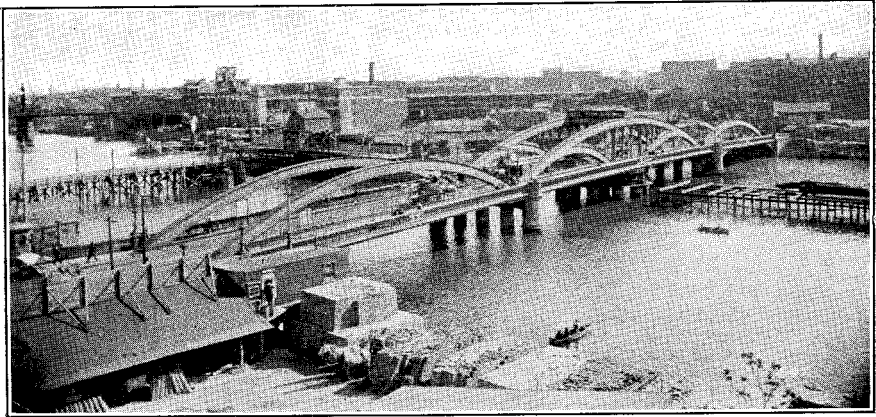


FIG. 1.—HARLEM BRIDGE.

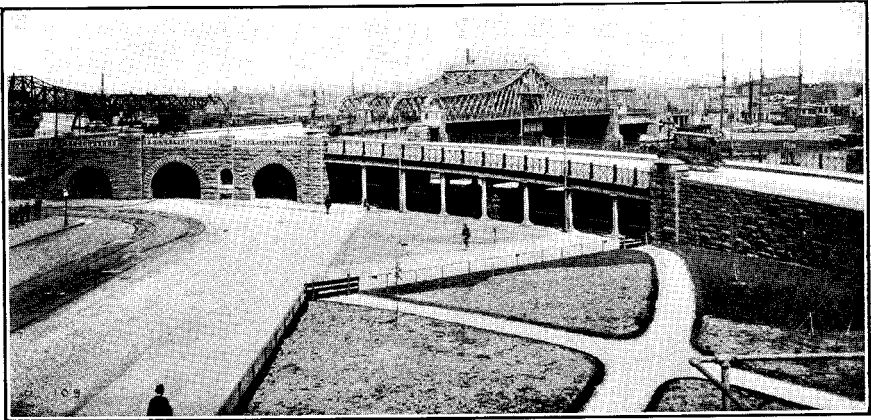
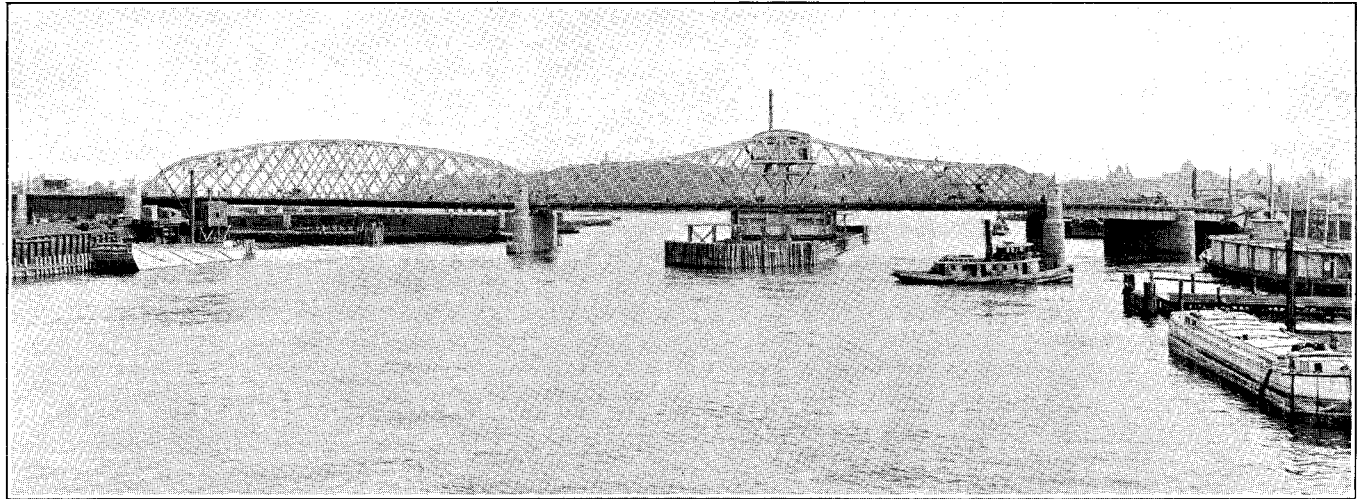


FIG. 2.—THIRD AVENUE BRIDGE.

PLATE XXIII
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GAY ON HARLEM RIVER BRIDGES.



WILLIS AVENUE BRIDGE.

DISCUSSION.

MR. CAMILLE MAZEAU, Member of the Society.—I would like to ask Mr. Gay if the Government fixes any minimum height from extreme high water to the clearance line of the drawbridges over the water. Is 24 ft. uniform throughout the United States? ✓

MR. MARTIN GAY, the Author.—It refers to Harlem River only. The minimum height of a bridge must be 24 ft. in the clear above high water at spring tides on the Harlem River.

MR. LEWIS.—You referred to McComb's Dam Bridge as, when it was built, the heaviest drawbridge which had been constructed. Did you refer to highway bridges or did you include railroad bridges as well?

THE AUTHOR.—That statement included drawbridges of all kinds.

MR. NELSON P. LEWIS, President of the Society.—May I ask how far work has progressed on the draw pier of the Fordham Heights Bridge; how deep you went there, and if you had any special difficulties?

THE AUTHOR.—No difficulty so far. The caisson is down 75 or 80 ft. and has perhaps 10 ft. further to go to rock.

MR. NOAH CUMMINGS, Member of the Society.—I would like to ask what the foundation for the pivot pier of the second McComb's Dam Bridge was? As that was put down before the time of the pneumatic process, it is interesting to know what system was used in a place where a pneumatic caisson would now be sunk.

THE AUTHOR.—That was in 1860. There had been some pneumatic work at that time. When the last bridge was building, the old piers were removed and the foundations blown up. They appeared to be composed of square timber cribs filled with loose stone. How that was put down I don't know, but the masonry was down below low water. I think they must have driven their sheet piling around the site of the pier and sunk their crib inside of it.

MR. CUMMINGS.—Then the bed of the river was dredged before the caisson was floated into place?

THE AUTHOR.—Probably dredged at first, though the bottom there is very hard, and I don't think they dredged out very much.

MR. LEWIS.—It has been rather surprising to me to hear Mr. Gay tell his story of the development of the Harlem bridges and see how almost impossible it has been to provide capacity for these bridges which would last a generation. Here is the Harlem Ship Canal Bridge, opened only nine years ago, entirely outgrown and has to be replaced by another. Of course, it may be said that this

is due to the fact that the Rapid Transit Railroad is to be built across it, but I am disposed to think that if there had been no Rapid Transit Railroad built over it the necessity for widening would have been very urgent.

Here is the Madison Avenue Bridge, built with a roadway 21 ft. wide, and the congestion on it is extreme. It seems almost impossible to design a bridge which will not, at the present time, be considered unreasonable in its dimensions, its capacity and its cost, which will do the work for which it is intended for more than a very few years. Mr. Gay has told me personally of the opposition which was encountered when it was proposed to make the Broadway Bridge across Spuyten Duyvil Creek a modern bridge, I think he said 100 ft. wide, and strong enough to carry modern surface railroads across it. The Ship Canal Bridge was not built with that in view. Now the Metropolitan Railway Company wants to extend its tracks across it.

MR. EDWARD A. BYRNE, Member of the Society.—The one thing that struck me, talking about the Washington Bridge, was the beautiful parks forming part of the approaches. I think that this question of beauty, which is coming up nowadays, ought to be gone into pretty thoroughly. I do not think there is anything of importance on Newtown Creek, or in Queens, except the movable bridge of the rolling lift type that we are building at Vernon Avenue. It is the first of its kind proposed for New York and vicinity. This bridge, I think, will be an adequate structure and will meet the requirements of this locality. It has a roadway of 40 ft. width and two 9-ft. sidewalks. As long as you allow for two car tracks and room either side for vehicles, I think that will be sufficient width for bridges crossing narrow canals.

MR. LEWIS.—Was there originally a bridge at East Avenue, or was the bridge moved up there?

MR. BYRNE.—That is part of the Grand Street Bridge.

MR. LEWIS.—I thought the old bridge wouldn't stand moving.

MR. BYRNE.—A new bridge was built at Grand Street over Newtown Creek.

The drawspan of the old bridge at Grand Street was of counter-balanced type. The short arm was discarded and new material supplied to make both arms of equal length, and this partly old and partly new structure was erected at East Avenue to serve as a temporary bridge during the construction of the new Vernon Avenue Bridge.

The contractor for this latter bridge removed the old Vernon Avenue Bridge. He advertised that he had a substantial (?) bridge to sell, but it was finally sold for junk.

MR. WILLIAM FOULKE JOHNES, Member of the Society.—I would

like to inquire whether any tests have been made showing the deflection of the draw span of the Madison Avenue Bridge under the heavy loads it carries. I have been on that bridge occasionally, shortly after the draws have been closed, when there were three or four trolley cars going in each direction, and it seems the vibration is excessive there.

THE AUTHOR.—No, sir; there have been no observations made of the deflections. It is a pin-connected bridge and therefore very flexible. The ends are supported by wedges instead of by jacks, and the support is not always rigid, so that there is a good deal of motion to the bridge, but that is due, I think, to those two causes—the character of its construction, pin-connected, and the fact that the wedges are not always driven home. A little change of temperature makes a difference in the fitting of the wedges and they are frequently somewhat loose, but the bridge is amply strong to carry anything that can be gotten on it.

MR. NATHANIEL H. ANDRUS, Member of the Society.—I would like to ask what became of the old Third Avenue Draw? I understood that it was carried away on scows somewhere and used in some other locality, I think City Island, if I am not mistaken.

THE AUTHOR.—There is a tradition that the draw span of the old Coles Bridge was taken up to City Island and did duty there until it was replaced by the new bridge which was recently built, but Mr. Theban, who has looked into that matter quite carefully, tells me that is a mistake. Some of the ironwork was used in the City Island Bridge, but not the span in its entirety.

MR. JOHN G. THEBAN, Member of the Society.—The old City Island Bridge and the old Coles Bridge were of entirely different types, and, as far as I can find out, only the tie rods were taken from the Third Avenue Bridge and put into the City Island Bridge.

MR. LANGTHORN.—We are building four small bascule bridges of the Scherzer type over the Gowanus Canal. The work so far has been mainly one of demolition. We have removed three of the old bridges and have one temporary bridge at Hamilton Avenue. The steel work for three of them has been shipped. There is not very much to be seen now, but in two or three months there will be.

MR. GEORGE R. FERGUSON, Member of the Society.—There is only one thing I might call attention to, and that is the difference between the Third Avenue Bridge and the One Hundred and Forty-fifth Street Bridge. The Third Avenue Bridge has three roadways, two of them for vehicles and the third or middle one entirely for trolley service. In the design of the One Hundred and Forty-fifth Street Bridge a change was made by making it a three-truss bridge with two roadways, the trolleys being put next to the center truss, thereby giving the roadways over entirely to traffic and not

devoting any special part of it to trolleys. The Bushwick Creek Bridge is a bridge similar in type to the second Third Avenue Bridge and was copied from it. It is built on cast-iron piles and was swung open once—then the contractors delivered it to the city. Since then it has been closed. They are gradually filling up that creek and in a very short time the bridge will have a solid bank under it and there will be no bridge left.

MR. LEWIS.—Mr. Gay, I would like to ask your judgment as to the point raised by Mr. Ferguson. What is your honest judgment, if you are willing to express it, as to the relative advantages of the three-roadway bridge, one with the central one devoted entirely to trolley cars and the two others to vehicles, and the two wider roadways which will accommodate both trolley cars and vehicular traffic? Does the devotion of the central portion of the bridge to trolley cars simplify the problem? Does it expedite traffic, or did you get better results from the two roadways?

THE AUTHOR.—We expect to get better results from the two roadways of the One Hundred and Forty-fifth Street Bridge. It frequently happens in repairing the asphalt roadway of a draw-bridge that we have to close one side. In the Third Avenue Bridge, for instance, whenever we make repairs to the asphalt pavement, we have to close one side and turn all traffic through the other. It is then in a very crowded condition, and the center roadway, which is used exclusively by trolley cars, gives us no help whatever, whereas if there were two roadways only with a car track on each, the quick-moving vehicles could dodge in between the cars on the tracks and the congestion would be very much relieved. Mr. Ferguson and I talked that over very thoroughly before the One Hundred and Forty-fifth Street Bridge design was adopted and agreed that the two-roadway plan was the most advantageous.

MR. LEWIS.—Is the central roadway paved?

THE AUTHOR.—It was paved with asphalt, but we have taken that off to lighten the bridge. The rails were raised above the surface of the asphalt, no aprons were provided to connect it with the fixed spans, and it could not be used for any vehicles except trolley cars under any circumstances.

MR. HERMAN A. RUGE, Member of the Society.—I have only a few words to say in addition to what our president mentioned about the development of this city. We have seen to-night how these bridges in the last hundred years have developed, what enormous sums of money have been spent, not only for their construction, but also for taking them down again and reconstructing them on larger and larger dimensions. It seems that they are not at present even adequate to take up the amount of increasing traffic for which they are supposed to be constructed. We can to-day say that

the Harlem River is situated almost in the heart of the city, and that the fate of the Harlem River will probably be the same as that of other creeks which have hampered the growth of cities; and the Harlem River will probably have to be filled in before the next one hundred years. The cost would not exceed that of two of those big bridges. Besides, those fine bridges may be used in future days as elevated roads for traffic, the same as they are now to a certain extent, but all the carriage traffic, the heavy trucking, and the general comfort of pedestrians is to-day very much impeded by these high and tedious approaches to bridges.

In other cities, for instance in Vienna, the "Wien," from which the city (capital of Austria) derived its name, and which is a small tributary to the Danube, has been arched over entirely and is just used as a sewer to-day. Also the large fortification ditches around the old city walls of Vienna have been filled in and are used to-day as big, lovely boulevards. The same fate has befallen such ditches in other cities, *i. e.*, in Nuremberg. In London, England, the Serpentine River, an old contributory to the Thames, is a sewer to-day. I have seen an old map in the British Museum in London with the title heading: "London on the Serpentine." And I think that by-and-by we shall come to the conclusion in New York that the best thing to do will be to get rid of that dirty, tidal Harlem River, which is of no real value to public navigation. The talk that the warships of the United States might have to make use of this little creek to pass from the Hudson over to the East River is a poor argument for the maintenance of the Harlem. The warships have the greatest difficulty to find their way in the big open bay of New York and its harbor. Besides all this, the Harlem River is a notorious malaria district, and the smell, especially at low water, is abominable. The Board of Health may have sooner or later to interfere and declare it a public nuisance, as it is nothing but an open sewer.

The Harlem ought to be turned over to the city to be transformed into a lovely boulevard.

Every one of us knows what an impediment to the traffic (not only to pedestrians, but to the surface cars, to the railroads, and to all vehicle traffic) a small sailboat, loaded with a few cords of wood, on the Harlem may be. Bridge after bridge has to be swung open, and the most urgent traffic has to wait patiently for a half hour or so to let a few cords of wood pass on a little sailing craft!

MR. LEWIS.—Mr. Theban, is any progress being made on the new Bridge over Eastchester Bay in Pelham Bay Park? Are you going to build the bridge that was designed and bids for which were received last fall? Is it a steel structure?

MR. THEBAN.—The plan provided for the foundations, piers and

abutments, six concrete-steel arches, 115 ft. center to center of piers, and two Scherzer rolling bridges, with a span of 60 ft. in the middle, a very ornamental structure. But the prices at the original letting were so high that the bids were rejected and a subsequent contract was made for the foundations alone. That work is now in progress.

MR. LEWIS.—In the first design of which you speak, for which bids were too high, it was reported that the cost was increased very much on account of the peculiar color which was demanded in the concrete, a sort of brick-dust color. Is that the fact?

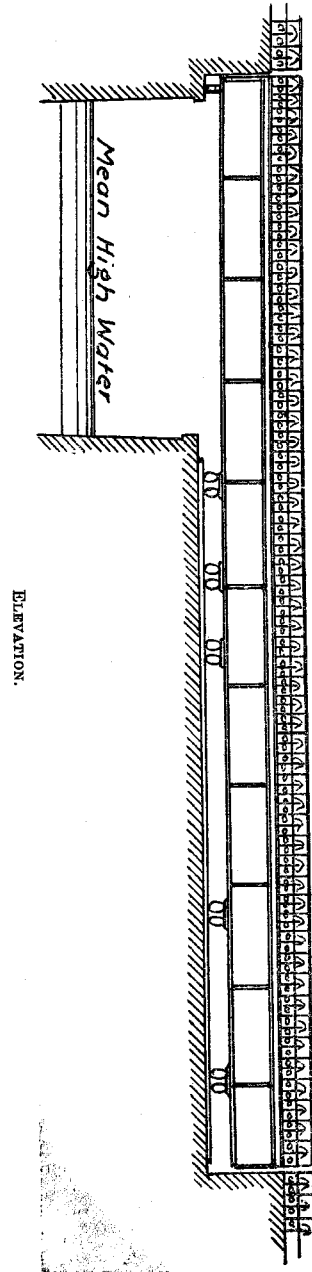
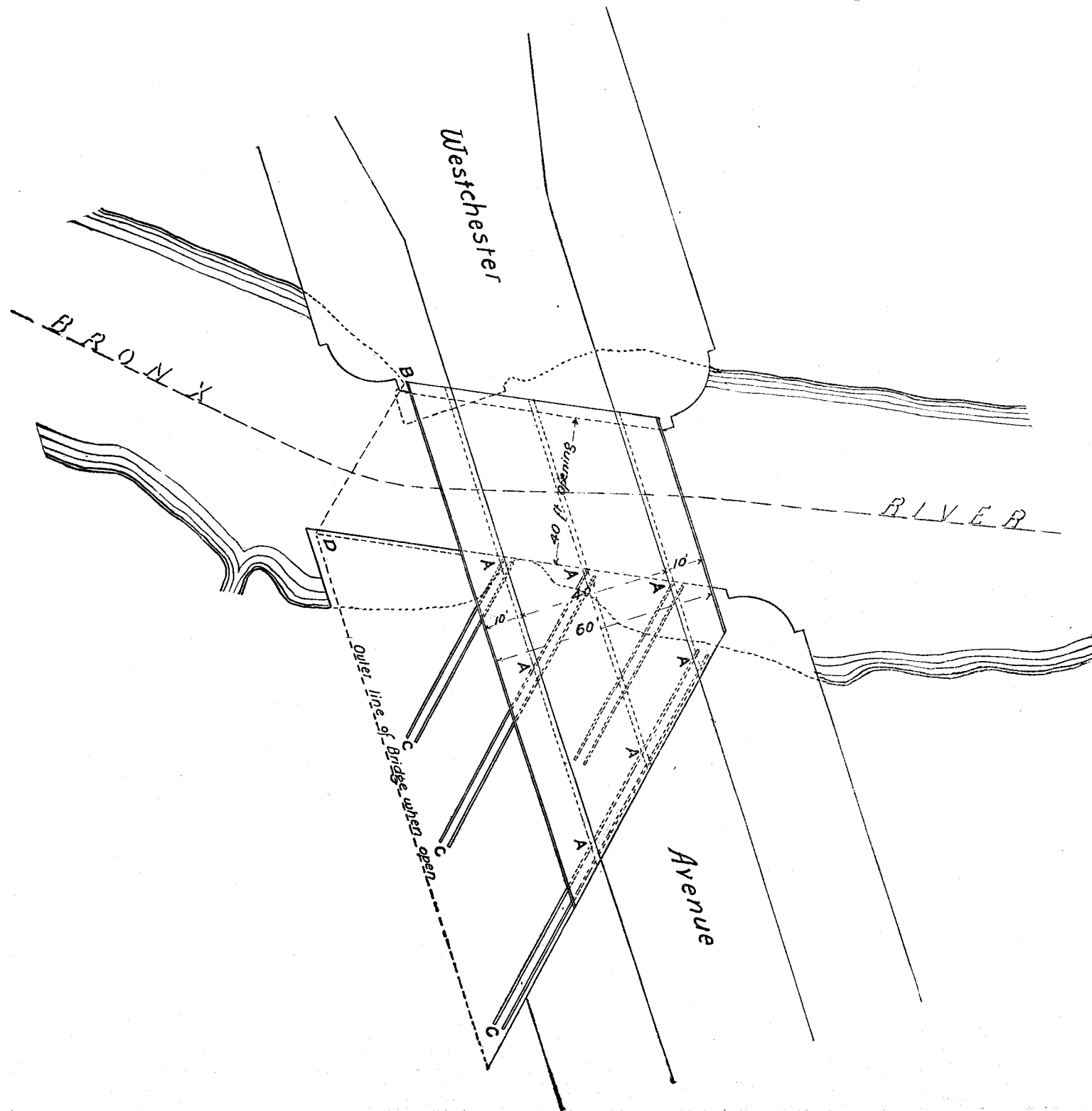
MR. THEBAN.—The two bidders on the first contract so told me. It was planned that all exposed surfaces, instead of being ordinary concrete, should be made of crushed bricks. It was expected that the cement skin could be washed off or picked off and that the particles of brick would show in contrast with the stonework of the piers.

MR. WILLIAM D. LINTZ, Member of the Society.—Is there any gentleman representing the Bridge Department in the Bronx who can explain the type of bridge at the Westchester Avenue crossing of the Bronx River?

MR. THEBAN.—The bridge is called by us the "Retractile Bridge," and I have also heard it called the "Boston Bridge." The type is used in Boston quite frequently, and also used by Mr. Langthorn for many years down in the Wallabout Canal and at Carroll Street. I think the best way to explain it would be to draw a diagram, and I wish you would call upon Mr. Ferguson to do that.

MR. FERGUSON.—The reason for the use of this type of bridge was the oblique angle between the line of Westchester Avenue and the line of the river, Plate XXIV. The three plate girders forming the main members of the bridge are supported on rollers or trucks at the points marked *A*; the short girder being counterweighted to prevent its tipping. In opening the bridge, the trucks move along the tracks from *A* towards *C*, the extreme corner of the bridge moving from *B* to *D*, leaving a clear channel in the center of the river.

The large amount of masonry and the land necessary for opening makes this type of bridge somewhat expensive and not as desirable as the bascule type when the channel is at right angles to the street; but in circumstances like those of this bridge it is, in my judgment, the best type to use.



THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

Paper No. 11.

THE HISTORY AND DEVELOPMENT OF THE TOPOGRAPHICAL WORK OF THE CITY OF NEW YORK.

**BY FREDERICK GREIFFENBERG AND WILLIAM S. DALRYMPLE,
MEMBERS OF THE SOCIETY.**

PRESENTED SEPTEMBER 28TH, 1904.

The municipal topographical work of the City of New York prior to 1870, when the city received the new charter (Chapter 137 of the Laws of 1870), was done by private engineers and surveyors, and we find in the records of the Department of Public Parks, a department created by this charter, that, having received jurisdiction of that part of the city lying northerly of Fifty-ninth Street, also of part of Westchester County lying adjacent and beyond the Harlem River, a bureau of civil and topographical engineering was established in 1870.

Under the regulation of the Department of Public Parks, this bureau had charge of the surveying for and the designing of all streets, avenues, roads, public squares and places, and their grades, and the plans for the sewerage and drainage thereof, and for all bridges, tunnels or other means of communication between the Counties of New York and Westchester, and of the improvement of the Harlem River and Spuyten Duyvil Creek, which by law now are or may be directed to be laid out and established by the Department of Public Parks.

The territory assigned to this bureau was divided into four divisions.

I.—THE WEST SIDE DIVISION.

This division embraces that part of the island extending from Fifty-ninth Street west of Eighth Avenue to the Harlem River and Spuyten Duyvil Creek.

Most of the work in this division, excepting actual construction, had been completed prior to 1870; the subsequent work consisted of extensions and modifications of lines and grades of streets and of setting monuments.

II.—THE HARLEM RIVER DIVISION.

This division embraces the Harlem River and the Spuyten Duyvil Creek.

The work in this division consisted of surveying and of designing plans for the improvement of the Harlem River and Spuyten Duyvil Creek, and for bridges and tunnels crossing these channels. The location of the bulkhead lines of the Hudson River from Fifty-ninth Street to One Hundred and Fifty-fifth Street had been fixed by an act of the Legislature in 1837, and, in 1857, the so-called Harbor Commissioners established new lines for the Hudson River and Harlem River, which latter bulkhead lines were superseded under Chapter 288 of the Laws of 1868, legalizing a map showing the new pier and bulkhead lines laid out and established by the Board of Commissioners of Central Park pursuant to Chapter 697 of the Laws of 1867.

The bulkhead lines laid out by the United States Engineers in 1892, which are the final lines, do not differ materially from those of the Central Park Commissioners in 1868, excepting that a new channel was created at Two Hundred and Fifteenth Street and the bulkhead lines of the Spuyten Duyvil Creek abandoned.

Surveys, soundings, borings, plans and estimates were made in 1872 for the suspension bridge at the site of the present Washington Bridge; also plans and estimates for a tunnel under the Harlem River in the same location where now stands the Central Bridge.

III.—THE WESTCHESTER DIVISION.

The powers and duties of the Department of Public Parks in relation to this district are prescribed by Chapter 826 of the Laws of 1869 and Chapter 797 of the Laws of 1870.

Chapter 826 of the Laws of 1869 gave jurisdiction over that part of Westchester County lying westerly of the New York and Harlem Railroad and southerly of the Village of Yonkers, and Chapter 534 of the Laws of 1871 extended the jurisdiction, including all that part of Westchester County lying southerly of the south line of the Village of Yonkers and a line in continuation thereof easterly to the Hutchinson River.

Topographical surveys were made under contract by William Rumble, Thomas C. Cornell and George S. Green, Jr., City Surveyors, and studies were made for a tentative plan for a street system.

IV.—THE EAST SIDE DIVISION.

This division embraced that part of the city bounded by Fifth Avenue, Harlem River, East River and Fifty-ninth Street. Plans and surveys were made for the Eastern Boulevard, but nothing was done to execute the plans.

These four divisions were in operation up to January, 1874, when, in consequence of the annexation to the City of New York of that part of Westchester County lying northerly of the Harlem River and the Spuyten Duyvil Creek, southerly of the City of Yonkers and westerly of the Bronx River, the sphere of the work of the Topographical Bureau in the Department of Public Parks was mostly confined to the newly annexed territory designated as the Twenty-third and Twenty-fourth Wards of the city.

The topographical work and the construction work were under one chief until 1877, when a special engineer of construction was appointed.

Tentative plans for a street system were prepared by the topographical force for the whole of the Twenty-third and Twenty-fourth Wards, on which curved roads and parkways were the main features, which plans were afterwards superseded by a rectangular system. The engineering force was small, the appropriations insufficient and very little progress could be shown.

The monumenting of streets was begun in such parts of the annexed territory where the population seemed to grow.

The former town of Morrisania, which was incorporated in 1856, had been surveyed and laid out by a special act of the Legislature, Chapter 841 of the Laws of 1868, and a complete plan of streets was filed February 21st, 1871.

The district was preserved as much as possible, but changes in grades and widths of some streets were made.

The former town of Morrisania contained 2 729 acres, on which 95.45 miles of streets were laid out, covering about 26.3% of the total area.

General plans for a street system on a scale of 150 ft. to the inch, covering the Twenty-fourth and part of the Twenty-third Wards, were prepared and filed between the years 1877 and 1884 as follows:

	Acres.
1. Spuyten Duyvil, Riverdale and Mt. St. Vincent District, covering about.....	1 585
2. North end and Woodlawn District, covering about.....	1 684
3. Boscobel, Fordham Heights and Kingsbridge District, covering about.....	1 711
4. Central District, covering about.....	2 220
5. West Farms District, covering about.....	1 443
6. Hunt's Point District, covering about.....	2 127
7. West Morrisania District (modified plan), covering about	280
8. South end of the Morrisania District (modified plan), covering about.....	848
9. Port Morris District (modified plan), covering about....	198
10. Highbridge District (modified plan), covering about...	221
Total.....	12 317

These plans were, to a great extent, remodeled between 1886 and 1890, but the filing of the same was omitted.

The laying out of the north end of Manhattan Island, north of One Hundred and Fifty-fifth Street, was also under the Topographical Bureau, and in 1884 a plan showing amendments to the so-called Serrell Map of 1869 was filed.

Chapter 411 of the Laws of 1876 directed the Department of Public Parks to make the tax maps of the Twenty-third and Twenty-fourth Wards, which very important work was carried on in the Topographical Bureau between 1876 and 1893. These maps were the result of a complete survey, thorough search of conveyances of property in the Register's office of Westchester and New York Counties, and are of such accuracy that surveyors and lawyers take them as a basis. There were nine volumes, aggregating 225 pages, in the Twenty-third Ward, and twelve volumes, aggregating 325 pages, in the Twenty-fourth Ward. The maps are drawn on a scale of 80 ft. to the inch, on sheets 18 by 24 in., and the total cost of surveying, searching, computations and three sets of maps was about 56 cents per city lot.

Chapter 579 of the Laws of 1880 required the Department of Public Parks to furnish surveys and maps to the Commissioners of Estimate and Assessment in the matter of acquiring title to streets, parks, etc., in the territory under their jurisdiction. This work was assigned to the Topographical Bureau. Proceedings to open streets and acquire title to land for park and other purposes were initiated in rapid succession, and there were times when over two hundred proceedings were pending. I may say that this branch of the Topographical Bureau at certain times monopolized the greater part of the force, which was particularly the case under the Board of Public Improvements between 1889 and 1902, when the engineering work for street openings of the whole City of New York was controlled by the Topographical Bureau.

The preparation of the designs for sewerage and drainage for the Twenty-third and Twenty-fourth Wards was begun in 1877, and complete plans for all streets in the Twenty-third and Twenty-fourth Wards, west of the Bronx River, were made in the Topographical Bureau, as also were the plans for the alteration and amendments where the original plans had not yet been carried out, and where conditions had changed.

Some of the largest sewers constructed in the Twenty-third and Twenty-fourth Wards are Farragut Street outlet sewer, 16 ft. in diameter; Brook avenue outlet sewer, 12 ft. in diameter; Broadway outlet sewer, 16 ft. in diameter, etc., etc.

In 1888, under authority of Chapter 721 of the Laws of 1887, the plans for depressing the tracks of the New York and Harlem Railroad were made in the Topographical Bureau, necessitating the establishing of new grades of all intersecting streets.

The above-described working of the Topographical Bureau progressed satisfactorily, but the property owners in the Twenty-third and Twenty-fourth Wards constantly and with perfect right found fault with the Department of Public Parks that very few actual improvements were made, and a bill was therefore introduced in the Legislature of 1890 (Chapter 545) which took the jurisdiction over the Twenty-third and Twenty-fourth Wards away from the Department of Public Parks and created the elective office of Commissioner of Street Improvements in the Twenty-third and Twenty-fourth Wards.

The newly elected Commissioner on January 1, 1891, established a Topographical Bureau and a Bureau of Construction under one chief engineer, and nearly all engineers, draughtsmen, etc., of the Department of Public Parks, engaged on work relating to the Twenty-third and Twenty-fourth Wards, were reappointed by him.

The main duties of the Commissioner were to prepare the final maps and profiles of the Twenty-third and Twenty-fourth Wards, in order to end the incessant changing of street plans which had made the people of the Twenty-third and Twenty-fourth Wards distrustful, and which prevented the growth of the district.

The whole force of the Topographical Bureau was employed from 1891 to 1895 in the preparation of a street and sewerage plan for the Twenty-third and Twenty-fourth Wards. The two wards were subdivided into twenty-eight sections, and street plans for all of them were filed before the end of 1895, as the law required.

The sections varied in sizes covering from 227 acres to 680 acres and defined 371.456 miles of streets, or one mile of street to about 28.2 acres.

These twenty-eight sections of the final maps were photo-lithographed and printed on three different scales, 150 ft., 300 ft. and 600 ft. to the inch, for use of the city offices, surveyors and for distribution to property owners; in the same manner the sewerage and drainage plans were photo-lithographed and printed, thereby

relieving public officials of many inquiries from property holders, surveyors and others.

By Chapter 934 of the Laws of 1895, the incorporated villages of Wakefield, Eastchester, Williamsbridge and part of the town of Eastchester and Pelham were annexed to the City of New York, to constitute part of the Twenty-fourth Ward of the city, and steps were taken immediately to make a triangulation and topographical survey of the annexed territory.

The force of the Topographical Bureau was enlarged and a branch office established in the new territory which lies east of the Bronx River and extends from the East River to the Sound. Part of this area was already in possession of the city, namely, the eastern half of the Bronx Park, the Bronx and Pelham Parkway and the Pelham Bay Park, which had been acquired under Chapter 522 of the Laws of 1884. Studies for main lines of avenues and streets were made, keeping in step with the progress of the topographical survey, and in August, 1897, a tentative plan for a street system, east of the Bronx River, could be adopted by the Commissioner of Street Improvements, which plan, although modified in some localities, holds good to-day.

On January 1, 1898, a second change occurred in the career of the Topographical Bureau.

The City Government, which had been organized in accordance with Chapter 137 of the Laws of 1870, underwent a change by Chapter 378 of the Laws of 1897, known as "The Charter Act," which created the five boroughs of the city, abolishing the office of Commissioner of Street Improvements of the Twenty-third and Twenty-fourth Wards, and establishing a Board of Public Improvements for "Greater New York."

I will not enter here into a description of the powers and duties of said board, because it would lead me away from my subject, but will state only that the Board of Public Improvements, recognizing the necessity of an engineering force, reappointed the whole force of the Topographical Bureau of the Twenty-third and Twenty-fourth Wards to serve directly under the President of the Board.

The Board of Public Improvements, having jurisdiction over the five boroughs of Greater New York, established branch offices in the

Boroughs of Brooklyn and Queens, in addition to the existing offices in the Bronx and Manhattan, placing them under one chief topographical engineer of the board.

These branch offices were organized identically after the former Topographical Bureau of the Department of Public Parks and the Commissioner of Street Improvements of the Twenty-third and Twenty-fourth Wards, which had been in existence since 1871 and had the practical experience of twenty-seven years.

The duties of this Topographical Bureau of the City of New York were:

FIRST.—To make a topographical survey of the City of New York.

SECOND.—To prepare the design for the street system, to determine the grades of streets and to make the maps for adoption and filing.

THIRD.—To define on the ground by stones and bolts the lines of the adopted street system and to protect and set monuments where improvements are being made in the streets.

FOURTH.—To prepare the design for a drainage and sewerage system.

FIFTH.—To make surveys, searches, technical descriptions and maps for the Commissioners of Estimate and Assessments in the matter of acquiring title to avenues and streets.

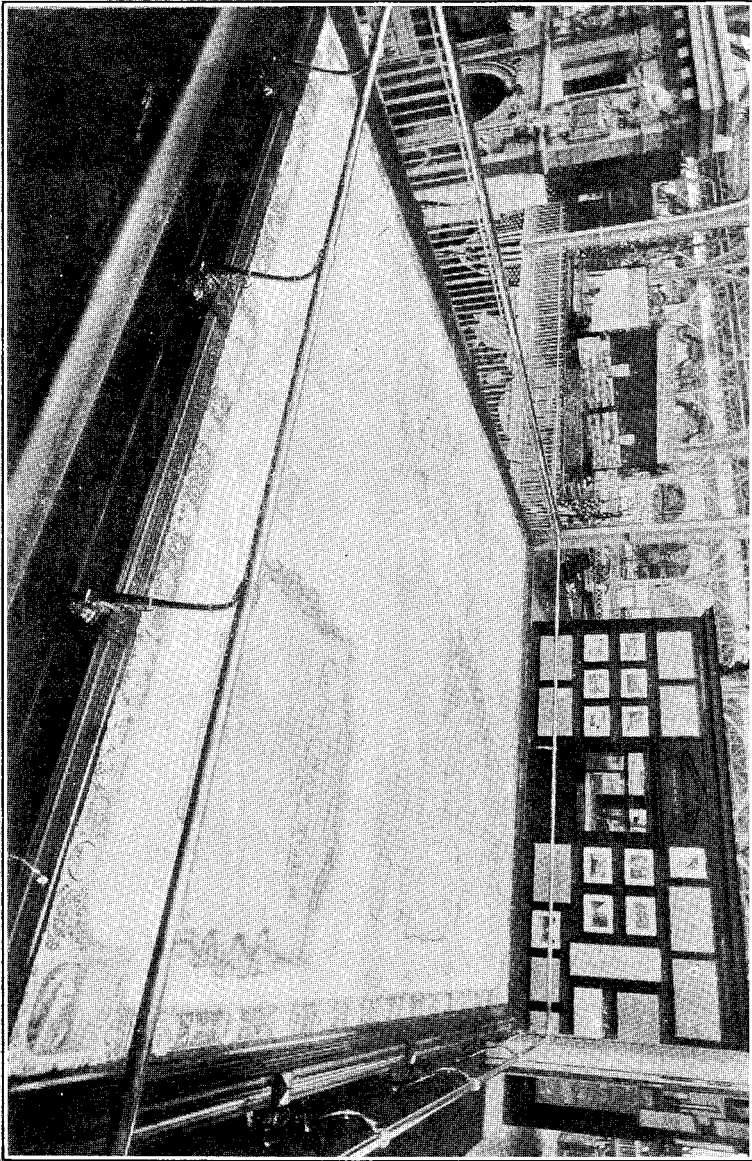
SIXTH.—To keep in custody the records and maps of all matters pertaining to the above-mentioned five items.

SEVENTH.—To make examinations, maps and reports on miscellaneous matters referred to it by the Board of Public Improvements.

The immense amount of work performed by the Topographical Bureau can best be learned by glancing over one of the annual reports of the Board of Public Improvements, and the one for the year 1900 is the best example, because in that year the large map of Greater New York was made for the Paris Exposition.

During this year 73 maps or plans pertaining to the five boroughs of the city were presented for adoption, and 53 maps or plans were prepared for filing; 732 monument stones were set, and 313 were re-set or set to grade. In relation to the street opening matters rule maps were made in 73 proceedings, draft damage maps in 85 pro-

PLATE XXV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GREIFFENBERG AND DALRYMPLE
ON TOPOGRAPHICAL WORK.



ceedings, draft benefit maps in 103 proceedings, and final copies of the damage and benefit maps in 96 proceedings; damage map surveys were made in 80 proceedings.

Investigations and reports were made in 409 cases, which involved very often the preparation of surveys and maps.

MAP OF GREATER NEW YORK.

In the year 1900 the International Exposition at Paris took place, and the Board of Public Improvements on January 17th, 1900, passed a resolution that the chief topographical engineer of the Board represent the Board at the exposition and take charge of the Map of the City of New York and such other exhibits prepared in the Topographical Bureau for this purpose.

These exhibits consisted of topographical maps of the city as the same existed in the years 1700, 1800 and 1900. These maps had been carefully compiled from reliable sources found in private and public archives and from public manuals.

The chief exhibit was, however, the map of the City of New York (Plate XXV), which has a size of 27 by 31 ft., and is drawn on a scale of 600 ft. to the inch. It was commenced August 1st, 1899, and was completed in January, 1900.

The map shows, in addition to the existing features, a tentative or proposed system of avenues, streets, parks, canals, viaducts, bridges, etc., over all the unimproved territory of the city in order to demonstrate how New York can be laid out as a modern city. The beauty of the drawing, the delicate coloring of the topographical features and the artistically executed border, with about fifty pen and ink sketches of the most prominent buildings and views in Greater New York, combine to produce a most pleasing aspect. The map was stretched on a heavy wooden platform and had an ornamental brass railing all around it. It received considerable attention from visitors, and the International Jury, on August 18th, 1900, awarded one grand prize to the City of New York, and to members of the Topographical Bureau of the City of New York two gold medals, six silver medals, seven bronze medals and eleven honorable mentions.

I may also add that the Chief Topographical Engineer of the city was selected as a member of the International Jury of Awards.

The year 1902 saw the last metamorphosis of the Topographical Bureau.

The charter of the city of 1897 was revised by Chapter 466 of the Laws of 1901, the Board of Public Improvements was abolished, and the work of the Topographical Bureau which extended over all the boroughs of the City of New York was placed under the charge of the respective Borough Presidents.

The large force of the Topographical Bureau cast their lot with the different boroughs in which they were stationed at the time of dissolution.

The Topographical Bureau of the Borough of The Bronx forms now one of the three divisions, namely, Topographical Bureau, Bureau of Highways and Bureau of Sewers, under the direction of one Chief Engineer of the Borough. In other boroughs the Topographical Bureau forms part of the Bureau of Highways.

The duties of the Topographical Bureau as now constituted under the Borough Presidents are, however, similar to those exercised under the Board of Public Improvements.

As an illustration of some of the work of the Topographical Bureau, it is proposed to give at the present time a short account of the topographical survey and triangulation of that part of the Borough of The Bronx lying easterly of the Bronx River, and at some future time a member of the Topographical Corps will read a paper on the actual field work and the methods pursued in that branch of the topographical work.

THE TOPOGRAPHICAL SURVEYS OF THE BOROUGH OF THE BRONX.

The surveys for the basis of the topographical work, anterior to the annexation of the district, east of the Bronx River, were made in detached bodies as the several emergencies called for such surveys. When the intervening gaps were afterwards filled in it was evident that a readjustment of the closed polygons farthest from the axis of reference was necessary; hence arose a system of transformation of co-ordinates. Such changes are analogous to that made necessary in the United States Coast and Geodetic Surveys.

PLATE XXVI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GREIFFENBERG AND DALRYMPLE
ON TOPOGRAPHICAL WORK.



The "Transcontinental Triangulation" joined together the different bases on the route traversed and a reduction to a common reference datum was made. Thus was adopted a "United States Standard Datum" for the purposes of the engineer and surveyor. For example, the line "Meades Ranch-Waldo" is common to the transcontinental scheme and to the 98th Meridian net. In adjusting the station "Meades Ranch" to this common datum, the latitude is changed 1.680 sec.; the longitude, 0.037 sec.; and the azimuth to "Waldo," 2.000 sec. The extent of this change may be appreciated if it be remembered that a second of latitude at this station is about 30 meters; of longitude, about 24 meters.

When, by authority of Chapter 934 of the Laws of 1895, that part of the present Borough of The Bronx lying east of the Bronx River was annexed to the Twenty-fourth Ward of the City of New York, a comprehensive scheme of triangulation for the new territory was undertaken. This district admits of a well-conditioned system of triangulation in that it is separated from the main body of this borough by the Bronx River, and from the Borough of Queens by the East River and Long Island Sound.

The initial step was the establishment of the northern boundary of the annexed district by the extension easterly of the present line between the City of New York and Yonkers. That part of such extension included between Mundy's Lane and the center of Hutchinson River constitutes a fixed boundary. The easterly segment of the boundary is that part of a line drawn from the easterly terminus of the south line of Yonkers to the mid-channel between Hog Island and Glen Island, included between Hutchinson River and the Sound. The remainder of the boundary is the irregular line dividing the old village of Washingtonville and the City of Mt. Vernon.

In order to be properly equipped for an intelligent reconnaissance of the ground with respect to well-defined points, a requisition was made upon the United States Coast and Geodetic Survey office for descriptions and geographic positions of a number of stations in the immediate neighborhood of New York City. In this manner were obtained the geographic co-ordinates of many stations used as a basis for connection with other stations in the triangulation net.

The annexed district was cut up into eleven subdivisions, a

field map of each made from the separate and several village and town maps, a surveying party assigned at first to each of two of these subdivisions, other subdivisions being occupied as the work progressed, until finally the whole field was covered.

For purposes of easily and quickly mapping the contour of the district, a line was run approximately parallel with Tenth Avenue, said line starting from a convenient station on the extension of the city line running southerly to intersect the Bronx River. This line was used as a base of operations for a leveling corps started in the field, after first establishing throughout the district a system of bench marks.

During the spring of 1896, after a complete tour of the territory involved, one suitable base line of over 12 000 ft. in length was selected across the salt meadow just west of Baychester Station on the New York, New Haven and Hartford Railroad, extending over a rocky knoll near the centre of the meadow northerly to a point near Hutchinson River, and southerly to a point south of the junction of the railroad with the Bronx and Pelham Bay Parkway. This line is called the Eastchester Base. A similar line, and of nearly the same length, was established through Eastern Boulevard, extending easterly to an intersection with Fort Schuyler Road, and westerly to the Classons Point Road. This is the Unionport Base.

For the main polygon, covering approximately 33 sq. miles, the stations High Bridge Water Tower, a description of which is deemed unnecessary; Dunwoodie, the central dome of St. Joseph's Seminary, near Yonkers; Hunter's Island, a tower on the mansion built upon the highest point of said island; and Jackson, a brick water tower on the Fort Schuyler Road, were selected. The stations Protectory, the spire of the main building at Van Nest, and Given, a tower on a vacant mansion near the intersection of Eastchester Road and Old Boston Post Road, are interior to the main polygon and connected therewith. Upon the distance Given-Protectory, derived immediately from the Unionport and Eastchester bases through a net of ten triangles, all the others depend, as will be shown subsequently.

The line Given-Protectory was connected with the secondary United States Coast and Geodetic line Memorial Church-Ferber

through the triangle Highbridge-Memorial Church-Ferber, the line Highbridge-Memorial Church being a part of the triangulation system of the Bronx Borough.

Ferber-Memorial Church, as per U. S. C. & G. S. = 28 306'.0.

“ “ “ as per Bronx System = 28 307'.2, or about 1 in 23 000.

Even to obtain this result it was necessary to use the least distance derived from total Unionport Base, and from the segments of the Eastchester Base. At that time the weight attached to the line Highbridge-Memorial Church was not known. Subsequently it developed that the station Highbridge had not up to that time been occupied by United States Coast and Geodetic Corps. However, this said least distance for Given-Protectory was retained, though giving a result too large for the United States Coast & Geodetic Survey line Ferber-Memorial Church, assuming for the Bronx Triangulation the chain of angles to be correctly measured within the limit of the instruments used, and the whole primary system made to depend on it.

In addition to these main stations, seventeen interior secondary stations were selected. The bases above named were cleared for a width of 30 ft., the termini of the Unionport Base were fixed, one at Station Crosby, the other at Station Ludlow; of the Eastchester Base, one at Station Maguire, the other at Station Red Oak. The bars for measuring these bases were of special construction, each capable of defining $\frac{1}{50000}$ of an inch. One bar, used as a comparator, had been sent to Washington for the determination of its length between zero marks, for the temperature at the time the test was made, and for the coefficient of expansion. The lengths of the other three bars were known in terms of this comparator, and consequently each bar had its special equation.

For the purpose of sighting over long lines and to be free from the irregular refraction near the earth's surface, nine towers, varying in height from 20 to 70 ft., were erected where suitable high buildings were not available or accessible. Communication was made with the State Survey Office as to the desirability of iron towers said to have been used in the State triangulation, but these towers had not been sufficiently tested to warrant an opinion. A

few galvanized angle-iron towers made by Aermotor Company were inspected, and were found to have many admirable qualities, but finally a decision was made in favor of the usual wooden towers.

The preliminary measurement by the 50-ft. chain of the two selected bases was made during the summer and fall of 1896. From December, 1896, to June, 1897, these two bases were staked at intervals of 16 ft., and measured by the bars in duplicate, though some of the sections were measured three times by the bars. The Eastchester Base was measured in six sections and the Unionport Base in four sections, though in each case tests were made with the stations, over twenty in number for each base, used in measuring with the chain.

In the meantime, final angles had been read in sets at the different primary and secondary stations. For example, at High-bridge, for the main polygon, there were read four single angles, then in combination of twos, then of threes, then of the four; and after each set the explement was read. This, excluding the explement, would make ten different angles; and generally for n angles, $\frac{1}{2}(n^2 + n)$, different angles were read. Again, these different angles were read in four different ways, that is, in the usual way a certain number of times, then in the reverse order an equal number of times. With telescope rotated 180° in the vertical plane, and then 180° in the horizontal plane, the angles were read in the direct way; and finally again in the reverse order. In this way, as a separate initial reading was used, most of the graduations on the plate were tested.

In July, 1897, the lengths of the Eastchester and Unionport Bases, as per bars, were calculated and a comparison made with the lengths as determined by the 50 spring balance compensating chain. The coefficients to be applied to the chain varied, in the Eastchester Base, from 0.999656 to 1.000161; in the Unionport Base, from 0.999333 to 1.000188; in the former passing through a range of .000505; in the latter, through a range of .000855 ft.

The four different chains in use before 1897 were found to have coefficients of expansion varying from .0000059 to .0000072, no two alike. In the matter of tension, these same chains varied from 7 lb. to 10.5 lb., again no two alike. In short, it is doubtful if an equation

has ever been determined for a chain in use by the Topographical Bureau before 1897. The difficulty of properly determining the constant equation of the ordinary steel tape is shown by the method pursued with the 100-m. steel tape No. 85 of the United States Coast and Geodetic Survey. In 1891, the following values were ascribed to the comparator interval D in terms of the iced bar B_{17} under a standard tension of 25.75 lb., the adopted elongation of tape per ounce being 0.041 mm.

August 1 to August 8, 1891, $D = 20 B_{17} + 39.52$ mm.

" 30 to September 5, 1891, $D = 20 B_{17} + 39.44$ mm.

" 3 to October 9, 1891, $D = 20 B_{17} + 39.37$ mm., where

$B_{17} = 5$ m. 18 microns,

and 77 observations were made, 66 of which per the Fahrenheit scale give

2	exponents between	.00000100	and	.00000200
1	"	"	.00000200	" .00000300
6	"	"	.00000300	" .00000400
6	"	"	.00000400	" .00000500
14	"	"	.00000500	" .00000600
18	"	"	.00000600	" .00000700
7	"	"	.00000700	" .00000800
2	"	"	.00000800	" .00000900
3	"	"	.00000900	" .00001000
5	"	"	.00001000	" .00002000
2	"	over	.00002000	

These variations cover a period of about three months and represent *hourly* changes ranging from 4 A. M. to 12 P. M.; while the observed temperatures range from 3.05° cent. to 31.04° cent. In the Coast Survey Report for 1892, Appendix 8, the following equation of this tape T_{85} is given:

$$\text{Tape 85} = 20 B_{17} + 22.35 \text{ mm.} \pm 0.020 \text{ mm.} + (1.0947 \text{ mm.} \pm 0.0021 \text{ mm.}) (t - 16^{\circ}.89 \text{ cent.})$$

While in the Coast Survey Report for 1901, Appendix 3, the following equation of tape T_{88} is given:

$$\text{Tape 88} = 20 B_{17} + 16.42 \text{ mm.} \pm 0.023 \text{ mm.} + (1.068 \text{ mm.} \pm 0.0040 \text{ mm.}) (t - 11^{\circ}.53 \text{ cent.})$$

with the assertion on page 265; there "seems to be good evidence that No. 85 has increased in length 0.45 mm., or 1 part in 220 000."

The greatest fluctuations in value occurred in the different measures of the two segments of the Eastchester Base.

The northerly segment—

By bars.....	equals 6 802'.396
By 50' chain direct, and unaffected by exponent	" 6 801.448 or 1 part in 7 100
By traverse through 9 761'.734 by 50' chain uncorrected	" 6 803.206 or 1 part in 12 000
By 300' chain, affected by exponent.....	" 6 802.149 or 1 part in 27 500
By Dock Department Triangulation	" 6 802.055 or 1 part in 20 000

The southerly segment—

By bars.....	equals 5 355.472
By 50' chain direct as above.....	" 5 355.031 or 1 part in 12 000
By traverse through 11 766'.152 by 50' chain.....	" 5 355.719 or 1 part in 48 000
By 300' chain as above	" 5 355.366 or 1 part in 50 000

It will be noticed that the mean of the direct and indirect measurements by the 50-ft. chain of the first-named segment differs from the bar measurement by 0.069 ft. or 1 part in 98 000; and in the latter segment the discrepancy is 0.097 ft. or 1 part in 55 000.

The field traverses were rigidly held in place through connection with the triangulation stations adjusted in the primary scheme. For obtaining the rectangular co-ordinates, the bearing of the north boundary line west of the Bronx River, and the distances and co-ordinates in said line east of the monument at the intersection of said line and the line of Tenth Avenue, are kept. This boundary line was directly connected with stations in the subordinate system, and thence with the triangulation net. In a continuously increasing number of ways the co-ordinates of the primary stations were computed, and then the co-ordinates of the subordinate stations. In the meantime the perimeter of each subdivision, as developed in the field traverses, was connected by two or more lines with the sub-

ordinate stations in the triangulation net. By this means the errors of any such perimeter, and of the enclosed space, were confined to the investing triangles. Thus we have but one system of co-ordinates in the annexed district.

To illustrate the cohesion of this system, the White Plains Road is laid out from the southerly boundary of Mt. Vernon to the Bronx River at Tremont Avenue; West Farms Road extends from the Bronx River along old Westchester Turnpike to the Westchester Creek; Tremont Avenue, from the Bronx River to a junction with Fort Schuyler Road, and thence to the Sound; Classon's Point Road, from Westchester Avenue to the East River; Gun Hill Road, from the Bronx River to Hutchinson River; Boston Road, from Pelham Bay Parkway to the northern boundary of the city; Two Hundred and Twenty-second Street, from the Bronx River to the Hutchinson River; Baychester Avenue, from the northwest corner of the district to Pelham Bay; East Two Hundred and Thirty-third Street, from the Bronx River to the Hutchinson River, near the city line; Castle Hill Avenue, from the West Farms Road to the East River. Thus we have a network of avenues 100 ft. wide conforming with the lines measured on the ground, connected with the triangulation system, and firmly binding all parts of the territory.

To recur to the determination of the fundamental distance Given-Protectory, it should be stated that these calculations were finished in 1898, when no other test than the United States Coast and Geodetic Survey line Ferber-Memorial Church was available, with the result as before stated. The logarithm of the distance Given-Protectory as derived from the Unionport Base was 4.1298057; as derived from the southerly segment of Eastchester Base, 4.1298115 or 1 part in 75 000, as derived from the total Eastchester Base, 4.1298118 or 1 part in 72 000. In the adjustment, accepting the logarithm 4.1298056, the logarithm of the distance Highbridge-Jackson becomes $4.5154685 = 32\,769.401$ ft. In 1899, however, a base line of over 12 000 ft. was measured on Jackson Avenue, Borough of Queens, both with bars and chains of 50, 100 and 200 ft., with an accuracy of 1 part in 100 000. This line was referred to two stations near at hand, and thence a direct connection made with the line Highbridge-Jackson. The logarithm of the preliminary

determination of this line from the United States Coast and Geodetic Survey line Bogart-Bergen is assumed as exceeding the logarithm 4.5154685 by more than 100.

The connection of the line Given-Protectory (logarithm 4.1298118) with the Queens Borough line gives for Highbridge-Jackson 4.5154797 or 1 part in 31 000, showing a result within the accuracy of 1 part in 25 000, before agreed upon.

In conclusion, it may be stated that the triangulation of Greater New York is now under way under the supervision of the United States Coast and Geodetic Survey office, and within a reasonable time we may expect an authoritative and official report on the whole territory covered.

DISCUSSION.

S. W. HOAG, JR.—I am not disposed to discuss this paper, but I would like to ask a question or two out of curiosity.

Away back in the early Eighties, when we were monumenting the streets east of Third Avenue, in the vicinity of West Farms, and the old Fox estate in the old Park Department, we found that as we proceeded northward we kept swinging off easterly from the theoretically correct positions of the monuments, owing to the cumulative effect of errors in the permanent monuments from which our traverses were run. There were some slight errors in the initial traverses down towards the Harlem River. The absence of such a very elegant system of interior or primary and secondary bases, of which the author of the paper in question has spoken, as marking the work in the easterly portion of the Bronx, was a serious lack at that time; for we had nothing of this character to connect with. We just simply ran, for instance, along Third Avenue, basing one system of traverses upon another one, the remote effect being analogous to obtaining a figure 6 in an attempt to close a circle; that is to say, we would have ultimately produced a spiral instead of a circle. I would like to ask if any connection has been made across the Bronx River between the new work described by Mr. Dalrymple and any of that old work, with a view of determining the deviation of any of those old monuments from their theoretically correct position.

W. S. DALRYMPLE.—I can partially answer that question. I would say that a connection was made immediately of the whole system, so far as the rectangular co-ordinates are concerned. They are based upon the boundary line between New York proper and Yonkers. When we proceeded with that system down the Bronx River Road to Woodlawn we were supposed to be in the same system, and when a connection was made on that basis directly with the monuments on the White Plains Road, a slight discrepancy was discovered. It was absolutely necessary to avoid these monuments on Webster Avenue in the triangulation system. If I remember rightly, the discrepancy was .1 or .2, that is, by taking those co-ordinates as they were in the local system. In connecting with points that we knew were in the triangulation system, even by way of traverses, we noticed this discrepancy. The original setting of those monuments was not at fault at all, but those monuments had been fitted in on something of a conventional scheme, such as Mr. Hoag says; among themselves they are consistent. When this

system is connected with another 5 000 or 6 000 ft. off, then the discrepancy is more pronounced.

HENRY W. VOGEL.—Mr. Hoag's question will always arise whenever we try to compare two kinds of surveys, the one assuming that the earth's surface is a plane with points established by rectangular co-ordinates, the other using triangulation points mathematically fixed on the actual surface of the earth.

All traverse lines are portions of great circles of the earth so that two parallel lines, say, two meridians, separated by one degree of longitude at the equator (approximately 70 miles), will intersect at the poles; similarly, if we prolong the lines of any two parallel avenues, the lines would intersect at a point on the earth's surface 90° from the starting points.

We cannot, therefore, compare points established in a system of rectangular co-ordinates based on the erroneous assumption that the earth's surface is a plane, although the actual measurements are taken on the earth's surface, with points mathematically established by triangulation.

MR. HOAG.—I understand that the easterly ordinate of a point in the vicinity of West Farms and Bronx River is approximately 20 000. An old rule in the Park Department was that an error of 0.15 per 1 000 ft. was permissible in traverse work. That would permit of an error then of about 3 ft. in such a point between its theoretical co-ordinates and co-ordinates obtained by direct measurement from the Tenth Avenue base. What I am trying to find out is whether any such connection was made with this accurate triangulation that would verify that deduction one way or the other, or whether any of those monuments referred to that we set in the early Eighties were connected with the triangulation.

MR. W. F. JONES, Member of the Society.—I think if the question was put in another form it might perhaps be better understood. It is simply this: If you are using monuments on both sides of the Bronx River, having the co-ordinates of the monuments on the west of the Bronx River with the old system, and those on the east with the new accurate system, what loss has got to be met?

MR. DALRYMPLE, one of the Authors.—Just use conventional lines there and reduce the co-ordinates on one side to correspond with the co-ordinates on the other side. Simply make them consistent with each other.

I will call the attention of Mr. Hoag to the fact that Mr. Vogel determined the latitude and longitude of the termini of the boundary line between Yonkers and New York. I was showing him the other day a verification of his work of determining the azimuth of points on that line; also that those azimuth differences were consistent all the way through. One extremity is near the center of the tracks of the New York Central Railroad at the city line, and the other is

a point said to be in mid-stream of the old Bronx River channel. These azimuths differ just exactly one minute, and that difference increases as you increase the distance, and increases in a certain direction, too, north or west. We have assumed an azimuth on Tenth Avenue of $28^{\circ} 50' 30''$. Mr. Vogel and I were trying to determine on what point on Tenth Avenue that is the true azimuth. I do not think we have decided upon it yet.

MR. VOGEL.—Mr. Haswell, in his pocketbook for engineers, states that the angle made by Tenth Avenue with the true meridian is $28^{\circ} 50' 30''$; this statement is indefinite, because it omits the location of the point on Tenth Avenue where such an angle is made. All true meridians are only parallel one to the other at the equator and converge towards the poles. The Tenth Avenue line is a portion of a great circle which is not a true meridian and, therefore, makes a different or varying angle with the true north at every point of its length. The convergence of meridian line accounts for the difference between the azimuth and the back azimuth of a straight line in a triangulation survey.

We have present to-night from all the boroughs of the Greater City topographical engineers who have much to do with the establishment of a street system. All public improvements, transit facilities, the construction of bridges, sewers, highways, the erection of buildings for residential and commercial purposes, to say nothing of the increase in valuation of real estate for taxation purposes, depend largely upon a well-defined street plan. Now, although we have heard interesting facts about carefully measured base lines and angles, and that it took from 1874 to 1895, twenty-one years, to lay out a street system marked with stone monuments and bolts, in that portion of The Bronx west of the Bronx River, it would be very interesting to know when the street systems will be established in the outlying boroughs, especially in Queens and Richmond.

MR. R. R. CROWELL, Member of the Society.—I desire to say that we have not progressed far enough to give much information about Queens Borough. We have only started.

MR. G. W. TUTTLE, Member of the Society.—I have nothing to say at present. The Coast and Geodetic Survey has been taken there in Richmond.

MR. G. W. TILLSON, Member of the Society.—Some reference has been made to the triangulation of the city that has been going on for a year or two now by or under the charge of a representative of the United States Government. It may be interesting to note that at the present moment, perhaps, if not during the evening, this party is now measuring a base line in the Borough of Brooklyn. They began work on it a day or two ago and are working every day from 3 in the afternoon until 10 at night, and they will be working there

two or three nights longer, and if any member of the Society has any desire to see how the work is carried on, he can do so very easily. I think they are on the Ocean Parkway now, and I was told this morning that it would take two or three nights after to-night, provided the weather was suitable, to complete it. The line will be about 12 000 ft. long.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

Paper No. 12.

PLANS AND SPECIFICATIONS.

BY J. V. DAVIES.

PRESENTED OCTOBER 26TH, 1904.

I am asked to-night to champion the side of the Contractor in relation to plans and specifications. This is a little foreign to my side of the question; for, for the most part, my work has been in the preparation of plans and specifications under which work has been executed. At the same time I have done so much work as Constructing Engineer and without plans and specifications, and I have also done so much work in bidding on plans and specifications and work for contractors, that I can feel sympathy with the contractor. There should really be only one side to this discussion. It should be a side of absolute fairness. The specifications, with the accompanying plans and with the contract, form one document. They are attached together, forming one legal instrument and representing a piece of work which any corporation or person desires to be executed and which a practical gambler, known as a contractor, desires to execute for profit. Under this agreement he desires to execute it for what is to result therefrom, and this instrument should be exact, lucid and correct, and it should convey from the one party to the other, from the brain of the engineer to the mind of the contractor, all the information necessary for the contractor to carry out the ideas of the engineer and to transfer into actual construction work the mind and imagination which the engineer represents.

As to the language of the specifications, it does not matter what the wording is, as long as it is clear, and as long as there is no ambiguity whatever in the construction. Errors and disagreement between clauses of the specifications always lead to difficulties in the completion of the work. There should be an absolute elimination of everything which is not absolutely relevant to the execution of the work and descriptive of the work itself. There should be no inclusion of any matter that is not strictly necessary to the carrying out of the work. In the preparation of the plans the object and aim should be the clear representation of the work to be done. In the preparation of the specifications the engineer should get himself into a judicial frame of mind, a frame of mind of absolute neutrality, with no idea of sticking a contractor, but with the idea of perfect equity. The best proof of the correct preparation of the specifications, outside of the actual carrying out and completion of the work, is found in bidding on the work. Bidding on work involves the study of every word and every condition and every sentence in the specifications from one end to the other, and it shows up, quicker than any other thing I know, the perfection of the specifications and of the plans. If the engineer could get himself into that frame of mind in the preparation of specifications and place himself in the position of bidding on the work, there would probably often be very much less difficulty in carrying out and executing the same. The preparation of the specifications and plans is, in the case of contract work, the hardest part of the work for the engineer to execute, and I thoroughly appreciate the difficulties which the engineer has to contend with in that matter. Elasticity in the specifications is often a very desirable thing, but in municipal work, far more so than in private work, elasticity is somewhat dangerous. There are no specifications ever yet made which were perfect; if they were, we would use one specification for every piece of work of the same sort and cut it off by the yard. The reason that no specifications can be perfect is that no one knows the conditions that govern and regulate any particular piece of work; the conditions always vary in every piece of work and the conditions are often an unknown quantity in the commencement of that work. In bidding upon work, and still more later in carrying out the work, the contractor wants

to be very clearly familiar with the personal character of the engineer he is going to work for. I, myself, have before now recommended a contractor to decline to bid on a piece of work because the known character of the engineer and commissioners who would have the regulation and execution of that work were such that I thought conditions in the contract might be very onerous and very hazardous. There is often inserted in specifications matter which is meaningless and sometimes is mischievous, on account, possibly, of the ignorance of the engineer as to the character of the work, or as to the methods which the contractor would decide to adopt in the execution of that work. Clauses are often inserted in specifications, as I think you all know, which seem to me to be there simply to hide or gloss over inexperience, or possibly, at times, the ignorance of the engineer who has prepared those specifications. The insertion of such matter is always a source of trouble in the carrying out the work, when the engineer, after making such ambiguous conditions, endeavors to take advantage later of the contractor in the carrying out of his contract. At the time of bidding on a piece of work a contractor is very chary of raising a kick on conditions. In relation to municipal work, any introduction of a kick or question would probably throw him out of consideration when the bids were presented. Further than that, every contractor who bids on a piece of work knows that there are a number of others—usually anywhere from six to a dozen—who are bidding on that work, and he has only one chance out of that number of getting the work. In addition to that, the contractor is well aware that kicking on conditions or obligations of a specification at the time of bidding is liable, if he should be fortunate enough to obtain the work, to queer him with the engineer. The engineering work should be done before asking contractors to bid. A thorough investigation of all conditions, the thorough consideration of all plans and all specifications, and all the requirements should be thoroughly worked out before bids are asked upon a piece of work. A contractor is often asked to bid on work which the engineer has not himself thoroughly considered. He is asked to risk, not simply his money, but his reputation as a contractor, and frequently on work which may cost the life of employees engaged thereon. On the

other hand, as I said before, the contractor is a gambler. It is equally essential that the engineer should study the contractors and should scrutinize very carefully those asked to bid, to make sure that they are competent to carry out the work which they desire to bid upon. Public work, municipal work, requires very different treatment often from private work. In municipal work it is usual that you will have to work under hard and fast appropriations, within which you have to keep and which limits you in the extent of the work. In private work that is not the case, and if there is any overrunning it is usually made right by proper explanation as to the reasons and conditions which involve the increased costs. I have great sympathy for that up-State politician who recently desired to take out of the conditions of the State canal work any option or discretion on the part of any engineer, and who desired, under process of law, to make it a hard and fast condition that the work should be executed absolutely in accordance with the plans and specifications, leaving no discretion to the engineer. At the same time, I appreciate it is entirely impracticable.

Now, as to the plans of work. The plans should be ample. They should be thoroughly detailed, as they form a part of the legal instrument, the contract, and go together with the specification to define the work and illustrate what is to be done. I think it is desirable, and I have found it so in my own experience, that the plans should, as far as possible, be uniform in dimensions and uniform in style. If there was less time spent on the printing of titles and more work put into the careful detailing and the careful figuring of the plans, there would be less trouble. I can recommend as a great help in titling and printing drawings the use of the printing press. I use one in my own office and pay a boy \$6 a week to set up type and print drawings. That does the work better than any ordinary draughtsman can print them and in a fractional part of the time. In plans accompanying contracts, usually there should be a map and profile generally illustrative of the scope of the work. In addition to that, all the details should be figured fully throughout, leaving nothing whatever to scale. Scaling of contract drawings often introduces difficulties and troubles. The plans should further show everything that is necessary for the calculation of the

quantities or should give the quantities. They should show how the quantities are obtained so as to enable the contractor to know if they are properly obtained and correspond to his basis of figuring. The engineer, it seems to me, should guarantee the quantities as worked out. It is not a just thing to ask a dozen contractors who are bidding to spend their money and time, with a force of assistants, to figure out the quantities which the engineer should do, and he should give in full detail to the contractor everything, in fact, necessary for figuring and estimating on the work. The plans should illustrate the specifications, amplifying all so as to make the instrument a complete one illustrating the work. The engineer should always be responsible for errors in the plans and in the specifications. It is not a fair thing to saddle the contractor with conditions obligating him to risk and liability of errors in the specifications or in the plans. Errors will creep in in the best regulated families, but the engineer is the proper party to take the liability and responsibility for figuring those quantities. I saw recently, in a magazine, a statement in respect to the incompleteness and insufficiency of plans, that in one of the most recent specifications issued by the United States Navy Department for one of the most recently constructed battleships there were inserted in that specification no less than 253 separate items, which stated that "these items should be built as directed," and there was no one who could give, at that time, apparently, any idea to the contractor as to what was required under the plans and specifications. They were simply to be built "as directed." It stands to reason that the contractors who were figuring on that work would figure high enough to cover anything that the Navy engineers might require in "building as directed." This, of course, is an exaggerated case, but that condition to a lesser extent is common in nearly all specifications and plans and will be familiar to you.

As to details of specifications, I have seen criticism in *Engineering News* some time ago of a condition specified in one of my own contracts, which provided, in the City of Brooklyn, that the geological formations would be the risk of the contractor. I did it because I could not make borings. Every time I tried to make borings I came down on boulders. At the same time, the criticism is a just

one from the point of view of the contractor. Why should the contractor be obligated to make examination of the soil before the execution of work? Is it not right that the engineer should thoroughly disclose in full detail to the contractor all of the conditions that are involved in the work? I know it is difficult. I know it is often almost impossible, but there is no impossibility and there is no difficulty in the engineer furnishing at all times to the contractor the fullest information, guaranteed as far as it goes and for what it represents; giving him records of borings, of the investigation of test pits showing the character of soil, and then stating those conditions so that the contractor takes the risk. I want to illustrate a particular case which happened in a work right in the Hudson River Tunnel. Ten or fifteen years ago one of our eminent engineers, since deceased, who is known by name probably to most of you, made borings and an investigation of the bottom under the Hudson River, and they were plotted very carefully on a map, which appeared to be thoroughly reliable. It showed the profile of the New York rock reef on the east side of the Hudson River running up more or less uniformly; borings were made at a distance of about 100 ft. apart. We were carrying on that work as constructing engineers, with no contractor. We came up to the point where the first boring which concerned us was located, and when we reached there, we took out a plug in the bottom of the tunnel, put a test rod down and found rock almost identically where that record showed it. The next boring was 100 ft. ahead and we proceeded toward that. Within 5 ft. after we made that test boring suddenly up jumped the rock in front of us like a wall, and we considered the borings were in error. When we came to the next location of boring, down the rock had dropped and the boring was essentially correct. Five times that condition occurred. Five times between borings were peaks of bed rock. That was an unfortunate condition. The record was perfectly correct. It was a risk the contractor ran. If we had been contracting, it was perfectly fair to supply all that information to the contractor and let him use his judgment whether that information was sufficient or not. If I had been the contractor in that case I would have said it was sufficient. As it was, it was a hardship on those who were constructing it, and you could appre-

ciate the hardship if you knew the cost involved by the conditions under which the work had to be done.

In the matter of excavation, the classification of excavation is often a source of difficulty. An "unclassified" excavation is a very much better one than one which is "classified." Give the information to the contractor. Tell him all you know and let him find out all he can find out, and then let him give a bid on the work as an unclassified bid—rock, loose rock, earth, hardpan, everything under one classification and at one rate—and you will probably find very much less difficulty in working out results.

By way of illustration, I want to point out, in connection with a set of specifications prepared by a very able engineer far away from New York, a few items that grind on a contractor. Here is one clause:

"The quantities above given are approximate only and the Board and Commissioners, etc., reserve the right to increase or diminish the amount of any or all classes of work or to dispense with any of them altogether, as they may deem best in the interest of the City."

Now, what chance has a contractor to bid on work of that sort? That obligates a contractor, first of all, to put in a plant that will cost \$40 000 for the plant alone, and reserves the right to the Commissioners to stop his work, to cut him right off at any time, and he has no redress and no ability to recover for the value of his plant.

In the same specifications:

"All face work of the brick lining in the tunnel and brick lining in the end shafts shall be carefully pointed, *if required*."

What contractor is going to figure on that contract unless he figures and includes for the pointing? If he includes for it and it is not done, the city is a loser; if he does not figure on it and is required to do it, then he is out. Why is it not made obligatory to include such a thing?

Now, here is one worse than that:

"The work shall be done in compressed air whenever, in the opinion of the engineer, the conditions are such as to require it."

Thus doubling the cost to the contractor. The contractor is required to put in an air-compressor plant and all the incidental machinery necessary, and the work is only to be done if required. A contractor would be a fool to figure on a job of this sort except at large figures to amply protect himself.

Further than that, it goes on with pages of the requirements covering the air-pressure work. ✓

Now, in relation to materials. The specifications for materials should be ample enough to insure and describe exactly what the engineer wants, whether it is first-rate, second-rate, fourth-rate, or any other rate. Samples and tests should be fully specified, even if they are not actually applied, but they should be in the contract so that the quality can be compared and enforced, if found necessary, as it is essential that the conditions and the quality of the materials which the engineer specified should be enforced and should be obtained. The material specified in every case should be such as may be obtained in the open market and in open competition, and yet such as to represent the quality desired by the engineer, or, what is in some cases better, specify arbitrarily some definite brand or manufacture which you know and can rely on. That is difficult and probably illegal in most municipal work, not all, because I have met it. I have done it myself in order to insure quality, where so many brands were on the market of which I knew nothing personally and could ascertain so little.

In the case of cement, it is very seldom in ordinary specifications for municipal work with which I have come in contact, for cement to be specified sufficiently fully to get the highest quality. I am sorry to know that there is often political or personal influence brought to bear to require the use of brands which otherwise I think most engineers would wish to exclude.

Take an item like sand. It is an insignificant thing in its way. Most specifications read that "*no loam*" shall be present. You cannot get sand that has not 2 or 3% of loam, unless it is washed. If you wish washed sand, specify it and pay the higher price.

Clauses are inserted such as this: "The contractor shall furnish all necessary assistance to the engineer, when required, without charge to the city." Where broadly stated and enforced it may be a great hardship, though probably and usually innocent enough. It is much better in a case like that to limit the extent of the assistance to be given, either to certain definite things or to pay at schedule rates for the labor employed.

Then there are classes of clauses employed in the specifications

that may be called "club" clauses. Here is one of them, taken from a municipal specification: "In case work under contract should be suspended or delayed by order of the Commissioner, all materials delivered shall be removed from the line of work, if so required by the engineer, and unless the contractor promptly removes the same when duly notified by the said engineer, the Commissioner may remove the same and charge the cost to the contractor." That involves the figuring by the contractor on a higher rate than he otherwise would do.

The postponement, delay and extension of time clauses I spoke of before are an injustice to the contractor. Usually the prices awarded to a contractor for a piece of work are too low to leave any possible profit if the absolute conditions of the specifications are lived up to. I know of one case myself in which I bid on some work and I bid on the rigid provisions of the specifications. I was told by the contractor by whom I was engaged, "Don't you take any chances on so and so. He is a martinet, and will make you live up to every condition there is." We did not get the contract. The man who did was broken in six months and the work was re-let at a considerably increased cost to the city.

The question of arbitration is an important one; it is a valuable one. Most specifications provide that the engineer shall be the sole arbitrator. If the engineer is a broad-minded, fair-minded man, that works out all right, but otherwise it is wiser and better probably to have some arrangement for arbitration.

A common clause inserted is "everything necessary to complete the work, even though not expressly mentioned in the contract." That is absurd on its face. The specifications should define and the plans should define exactly everything provided under the contract. Has an engineer the right to shift all responsibility for the carrying out of his work? Has he a right to turn over a piece of work to the contractor and say, "There are my plans and specifications, all the responsibility is yours, everything is yours?" I had that condition to meet on the Atlantic Avenue improvement work in the danger of operating railroad trains on the surface above the excavation, and I did not care to leave the responsibility with the contractor, notwithstanding the contract obligations. If a train had

ever gone down into that ditch there would have been 50 to 100 people killed, and the company would have stood the brunt. I have employed, ever since the commencement of that work, a force of carpenters, who never left the work for any length of time, night or day, whose duty has been to go over the timber and see that the contractor has left it in shape and secure. I think the engineer is responsible for the performance of his duty, irrespective of whether the contractor carries out his or not. No provisions should be irksome to a contractor if they are clearly known and understood at the time of bidding, obligating him to do anything whatsoever which it is in his own power to control. The hardship and injustice is found when those obligations are beyond his government and control. Conditions, the execution of which, put upon the contractor cost, expense or risk (and risk, mind you, is in itself an expense, entitling the contractor to a cash consideration) beyond that which was originally figured and bid upon. Generally speaking, it is fair and proper for the contractor to fulfill and execute anything stated in the specifications or shown on the drawings, provided it is capable of definite determination and estimate at the time of bidding, whether it is good or bad engineering. To an honorable contractor—and I am glad to say there are a great many of them, though there are a few otherwise—the more rigid and the more onerous the specifications and plans can be made, shutting out irresponsible bidders, the better the contractor likes it and the better for the company for whom the work is being executed. At the same time the engineer must estimate the value of the work on the strict interpretation of the specifications and plans as they are drawn and drafted, and on the understanding that the work will be handled in a careful and economical manner by the contractor. The corporation or the city is entitled to the work represented in the contract and the contractor is obligated to deliver it. It is a mutual dependence, with profit to both.

DISCUSSION.

PAPER BY MR. J. C. MEEM.

If it were possible for me to compress into a single word the meaning of that which I should like to say to you this evening, I could not do better than select "co-operation" as that word—co-operation between the engineer (as representative of the corporation or municipality), on the one hand, and an imaginary contractor on the other.

You may say that it is not possible to co-operate with an imaginary person; what is true in the concrete only, and not in the abstract. You may say again that the possibility of opening up a wider field of graft under the guise of co-operation is too great. My answer to this is that the old type of contractor, standing as a bar to all progressive ideas, and seeking only to "do some one else before they do him," is fast becoming a myth, and in his place stands a new type. A broad, progressive man, not infrequently an engineer himself or possessing the qualifications that go far toward giving practical value to an engineer's education, and who has not only his money at stake, but his integrity and reputation as well—it is with this man that I ask you to co-operate.

It is possible to consider only a few points which might be of interest in the treatment of this broad subject, for I may tell you frankly that I do not believe it will be possible to find a perfect adjustment of the conditions under what I may call the present idea. And by the "present idea" I mean that impression of conditions between the one extreme in which the engineer is also the operator and constructor, and the other in which the contractor furnishes the designs and plans as well as the estimate. The first, of course, presupposes that the engineer in all cases is experienced in practical construction as well as in designing and estimating—and by this I do not mean that he should know only how work should be done, but that he should also be able to carry it out by the safest and most economical method—*i. e.*, he should possess practical experience now vested in a plurality of contractors. The last case supposes that the contractor is a capable engineer or has engineers of sufficient ability to design and estimate, and that his own integrity is sufficient to guarantee his work beyond the visible face. In the one case the municipality says to its engineers, "Design and build a certain structure, advertising for bids only for labor and materials to be used under your direction."

In the other case this municipality says to the contractor, "Send us in your plans and estimates for a certain structure; where the

plans are satisfactory the work will go to the lowest bidder." You can see, gentlemen, that the time for this is not yet up and we must take up the burden where it lies. How, then, can you co-operate with your prospective contractor, so that your plans may be carried out as you propose and within the limits of your estimate?

To my mind, the accomplishment of this result may best be secured by the most careful study, not only of conditions, but of methods as well, and by the more frequent adoption of alternative plans and designs. Of course, alternative plans are of value only where the conditions are partially or entirely hidden, as in foundations, or in tunnel work, and are not so necessary as in bridge work or paving. An instance will serve to show the application of what I claim to be the necessity for alternative plans. Suppose you are designing a small sewer tunnel through saturated ground, and it is essential that the ground-water be excluded, and the sewage be kept in by means of the most careful waterproofing. You estimate on the increased cost of an excavation at least 3 ft. larger than that required for the extrados of the arch measured along the radius, in order that your waterproofing may go satisfactorily and as specified.

Your bids are all in and are based on this extra excavation, except that of one man who explains that he is low because he can do the waterproofing satisfactorily within the neat limits of the excavation.

What are you going to do? Alternate plans or even a clause in the specification would have set the whole thing right. Now, no matter what you do, injury must be wrought some one. Another instance—suppose you are designing a subway to run beneath car tracks on which traffic is to be maintained during construction. You propose a design involving reinforced concrete, and, in order to co-operate fully with your contractors, you invite them into a conference. They assure you that the design is not practicable; that you will have to give them a steel-beam-roof construction. And that heavy side walls must first be built in trenches; the pipes and sewers must then be relaid and the structural beams thrown across from the sidewalks, from which the tracks may be supported during the subsequent construction.

They tell you that the increased cost of material will be more than compensated by the cheapened construction (*sic*). You are overruled and give them the more costly design. This appears to me to be a case of too much co-operation, for if the original design had been adhered to it is probable that you could have found a bidder on your plans and within your estimate. In any case, alternative plans would have assured the city of a substantial structure and in all probability within the limits of the estimated cost.

This, then, would appear to offer a simple solution of some of our problems in co-operation: Alternative plans before the letting and

such reasonable wording of the plans and specifications as to allow for requisite alterations or changes after the contract has been let. And while I believe the tide of opinion is beginning to act this way, I feel that we ought to do all in our power to help it along.

The following minor points have occurred to or been suggested to me as being of interest in the consideration of those points in which plans and specifications are sometimes faulty: ✓

1. Where they go heavily into the details of one point and fail to clear up the mysteries of another. ✓

2. Plans drawn so clumsily that they require interpretation at every turn, sometimes giving the interpreting engineer a false idea of his importance. ✓

3. Specifications which enumerate certain precautions that the contractor is required to take to protect his work and of necessity omit numberless others. It seems to me that if you are going to let the contractor take the responsibility for his plant and his work, you should not hamper him with conditions, and if the responsibility is yours, assume it clearly. The mention of a few points naturally exclude those not mentioned, whereas a sweeping clause covers everything. Why not say "the work shall be properly safeguarded during construction" and let it go at that. ✓

4. Specifications prohibiting that which would be disastrous under an ordinary type of construction, but which might be of advantage under a new or special type.

5. Specifications full of ambiguous phrases and of antique clauses which have been copied into them from one generation to another, no one knows whence or why, and which simply serve as a clog and a drag.

It has been found that a separate set of specifications carrying all materials to be used, standardized and revised from time to time and kept on file, so that for covering each contract short and simple specifications can be written which can readily be read and referred to, is of advantage, and would appear to offer an example which can be followed. ✓

Between the limits of those specifications which go into the minutest detail concerning everything, and those which recite "That the contractor shall do the work as required by the engineer," there is a specification for which the contractor is anxiously waiting. ✓

And now something as to the interpretation of specifications. When we realize that the specification is a one-sided affair at best, that the contractor is frequently required for his own preservation to enter into a contract which is distasteful to him, and for doing work which would be simple if not sometimes hampered by what he considers useless restrictions, can we wonder at the fighting qualities which most contractors develop; and when we realize that no specifications can be written which will not retroact at times, can we

blame the contractor for combating every clause that seems to hamper his work? Whom, then, will you send to meet the contractor in the combat, an inexperienced man with full knowledge of the letter of the specification, but totally ignorant of the practical value, or a narrow-minded man who will enforce the letter only and pass over the broad spirit of fairness which lies beneath; or one who will attempt for his own glorification to read into certain clauses meanings not intended to be there; or a capable man, but with no authority to act save as a buffer for the combat, an errand boy between you and the contractor, or a pack mule on whom to lay the burden of your errors?

Or will you send a capable, broad-gauged, experienced man, with full power to use his judgment when it shall be required, and who will do all in his power to push the work and help the contractor so long as it is within the broader limits of the specifications?

And now just one word to you who are sent, are you going with a full knowledge of the combat that lies before you, or are you in absolute ignorance of it all, like the inspector who was sent to a certain navy yard? Walking up to the superintendent he said, "I have come to inspect your teak wood." "We have none," said the superintendent, shortly. In a short time the superintendent was called up before the Chief Engineer. "Why," he said, "did you tell my inspector that you had no teak wood?" "Because, he answered, "the d— fool was leaning against a pile of teak wood when he asked that question."

Gentlemen, are any of us leaning against a pile of teak wood we have been sent to inspect?

MR. GEORGE W. TILLSON, Member of the Society.—The problem of the making of plans and specifications for any work is more difficult than a great many people think, because no matter how simple the work itself may seem, a great many people, like corporations, are uncertain themselves as to just what these plans and specifications ought to show. Unfortunately, every one does not believe that the plans and specifications should give all the knowledge that they can. A gentleman, whom many of you know by reputation and who stands very high in the community, once said that he believed in receiving lump bids for work, because the contractor would generally forget something and consequently would bid low. I do not believe it good policy for an individual or a corporation, whether the corporation be public or private, to have work done for anything less than a reasonable sum. The contractors are in business for money, not for their health, and it is only natural that if they find that they have been fixed, or used in some such way as this, to put in a bid for less than the work can be done, to try and get out of it, and I don't know that I blame them very much. It seems to me that

the plans and specifications should show everything that it is possible to show about the work to be done; that they should give to the contractor all the information that it is possible to obtain.

✓ Now, as has been said by the gentleman who first spoke, it is not fair, on a large and expensive piece of work, where there may be twelve or fifteen bidders and where you want all of the competition possible, to say to those twelve or fifteen contractors that each one of them must make an individual investigation of the conditions involved in carrying out the work, when the city or private corporation or individual could make these investigations and furnish the facts to the contractor. In one case it is going to cost twelve times as much as in the other, if you have twelve contractors, because you all know how carefully each one of these contractors will keep any information that they may be able to obtain from the other, and so it does seem that in the interest of the corporation and in the interest of the contractor it is only right for the corporation to make as fair an investigation as possible, and furnish all the facts possible to the contractor, because in the long run they are going to pay for all of these investigations that are being made by the different contractors, and because what the contractor loses in making his investigations for one contract he will make up in the profits on another. ✓

Now, that part is not so simple, because it is a question, if you attempt to furnish information, whether you ought to furnish all the information necessary. Sometimes you may think you do it and you may not, and if you do not and you find your information is wrong, then it is only fair to the contractor to pay him for the extra cost, if any, that he is put to in carrying out the work, and in municipal work that is not a very easy thing to do. It has always seemed to me that if, for instance, on a sewer contract, you showed that in a certain part of the work a contractor is going to encounter water, for instance, on four or five blocks in a contract that involves twenty blocks, and he finds it, instead of on four or five, on the whole twenty, it seems to me he is entitled to extra compensation for that, because if you show four I think he is entitled to take it for granted that water is on those four blocks and not on the rest.

Then contracts often run the other way and the specifications furnish very little information.

I remember quite a number of years ago contractors were bidding on a contract for constructing a sewer system in Macon, Ga. It was a system for the entire city, but was divided into four districts. You could bid on one district or all. I studied three of the districts pretty carefully from profiles and the work, and then I looked for the plans and profiles for the fourth district and could find none. I inquired of the City Engineer what they were going to do about District No. 4, and the reply he made was: "Well, you

will have to go down to the district, look it over, and then make up your own mind how deep the sewers will be." I went down to District No. 4 and found about half of it under water; but we had to bid and take the chances. The bid I was connected with was \$138 000 and the contract was let for \$100 000. The contractor worked on that a little while when, as Mr. Davies said, he was broken. The plans and specifications were prepared, too, by an Eastern engineer, who is a good engineer and has a good reputation in this vicinity.

Another thing about specifications is that they want to be concise. You want to specify what is to be done. Give the contractor all the information he needs as to what he should do, but do not attempt to say too much. If you attempt to say too much, you will often do just as much harm as if you say too little, and your specifications may be inconsistent when you think they are not. A good illustration of that came to me in carrying out a contract in a western city, where the bidding blanks said that the price per foot should include the cost of work complete and also the taking care of all railroad tracks encountered. It was a sewer contract, and before I went there the work had been constructed under a number of railroad tracks, where the contractor had shored them up and taken care of them, and after I had been there a while he had to go through a railroad yard—it was then the Rio Grande Railroad—where there were twelve or fourteen tracks to be gone under. A few days before that I was looking through the specifications and I found a clause that read somewhat like this:

"The contractor shall provide for all railroad companies every facility in taking care of their tracks."

That struck me as rather peculiar, when in the first part of the contract it said that the price per foot should include that. I spoke to the other men connected with the contract and they said there would be no use in calling attention to it as nothing would be done about it. I said it would not do any harm to try. And that reminds me of a fact that may not have occurred to you all: that when a contractor comes before you for extras you must not think for a minute that he expects to get all he asks for; very often if he gets nothing, he goes away satisfied. But in this particular case the Board of Public Works, who had charge of the sewer, had on it a man who was an engineer and had been a city engineer, and we went before him and I told him that under that clause I thought we were entitled to some help at least in carrying out the work, and he finally wanted to know what I wanted. I said I wanted the city to pay for going under those tracks. Well, he laughed at me, as I expected he would, but I said, "Tell me, Mr. ———, if that clause does not mean that the city or the railroad company will take care

of their tracks, what does it mean?" He could not answer. There is no reason why it should have been put in. If it had not been there, everything would have been all clear. The result was, we got an allowance for going under the tracks.

It often occurs that, in making specifications, it is difficult to be explicit. There are certain things that must be left indeterminate and unsettled and to be decided upon by the engineer. Now, I do not suppose that at the present time there is anything or any one class of work that is more difficult to draw up exact specifications for than asphalt pavements. It is almost impossible to specify anything positively about asphalt itself. When asphalt specifications were first written they were, as I presume you all know, prepared by the asphalt companies, for they were the only ones who knew anything about the work, and that was not very much, and cities had to rely upon the five years' guarantee. There was a clause in most of them that read something like this:

"The asphalt used shall be of such a consistency that will produce a pavement that will not be soft in summer and will not crack in winter."

Well, now, that is a very good specification as far as results are concerned, but how that result is to be reached or what should be done to reach that result nobody knew. Then it makes a great difference in writing specifications who is going to pass final judgment on the work. Without casting any reflections upon any other department or any other bureau of the government of this city, all those of us who have charge of work being constructed here know that it must be passed on by two different departments after it leaves our own, so that an engineer in the city who is drawing specifications must protect himself to a certain extent. He knows that his work is going to be passed on by the Finance Department and by the Commissioners of Accounts, and I want to say that the passing on work and on the specifications by the Commissioners of Accounts and the Finance Department is always a great help to the engineer, but it depends a great deal upon the spirit in which these other departments criticise any specifications and criticise the work carried out. Because it is so difficult to specify exactly what you want in the case, particularly of an asphalt pavement or anything of that kind, and if you do put in certain specific things and it is practical to carry them out exactly, the first thing that you hear is that specifications are not being lived up to, so that an engineer must leave certain things to be passed upon by himself at the time the work is being carried out. While, in a certain sense, I believe that is wrong and, as was referred to by the first speaker, that there should not be anything left to the engineer in carrying out work, we all know that it is impracticable and the engineer must decide on certain things while the work is going on.