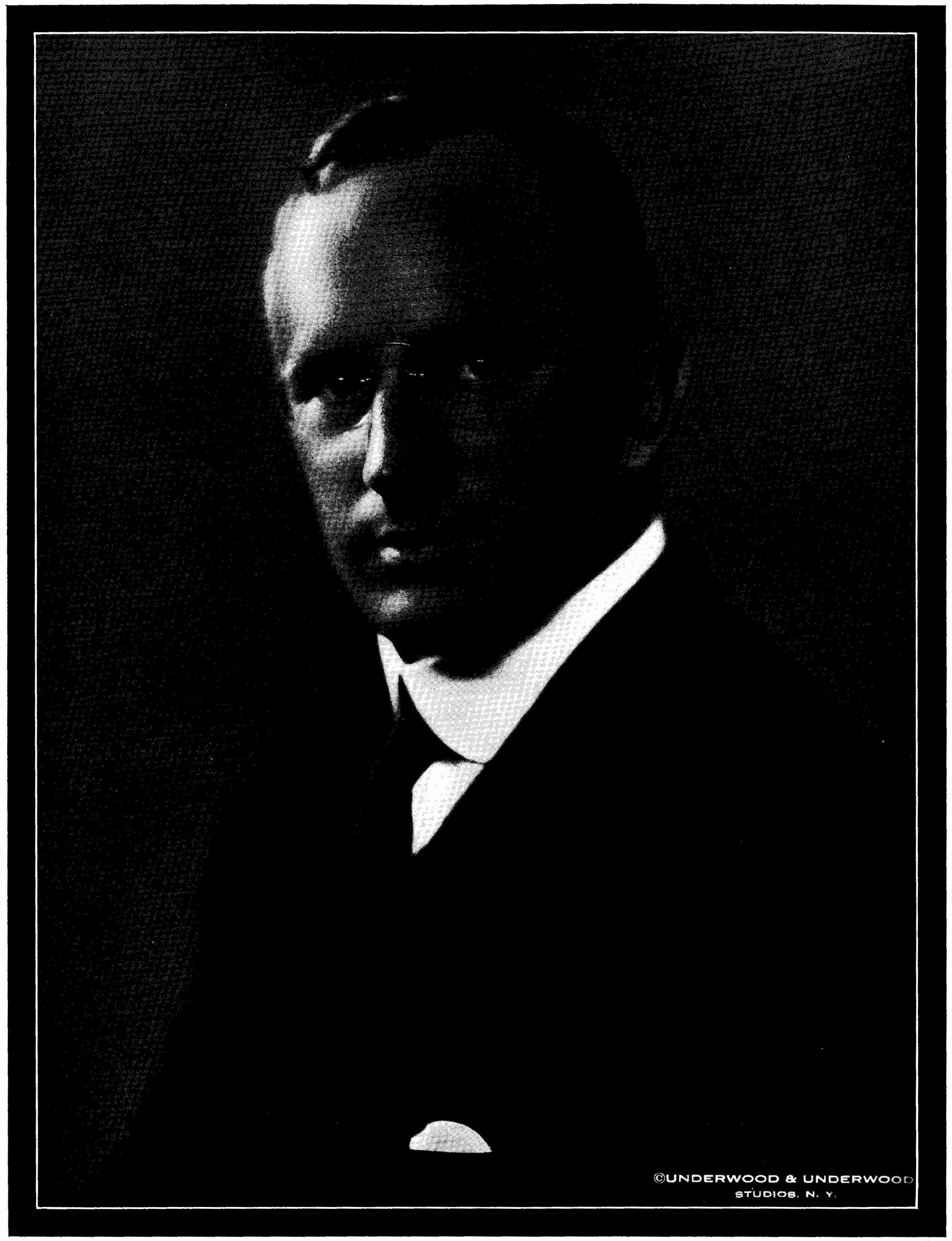
REPORT

OF THE

New Jersey Interstate Bridge and Tunnel Commission

1925



CLIFFORD MILBURN HOLLAND.
MARCH 13, 1883.
OCTOBER 27, 1924.

REPORT

OF THE

New Jersey Interstate Bridge and Tunnel Commission

TO THE

Senate and General Assembly of the State of New Jersey

THE HOLLAND TUNNEL

THEODORE BOETTGER, Chairman
THOMAS J. S. BARLOW
JOHN F. BOYLE
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MILTON H. FREEMAN, Chief Engineer
JOHN C. McENROE, Secretary

DATED JANUARY 2, 1925

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1925

New Jersey Interstate Bridge and Tunnel Commission

ANNUAL REPORT

To the Honorable Senate and General Assembly of the State of New Jersey:

The New Jersey Interstate Bridge and Tunnel Commission respectfully submits its annual report for the year endng December 31, 1924, dealing with the construction of the Hudson Vehicular Tunnel, now known as the "Holland Tunnel." The stewardship of the Commission as it relates to the building of the Delaware River Bridge will be accounted for in a report to be submitted by the Delaware River Bridge Joint Commission. Harmonious relations which have continued to exist between this Commission and those of New York and Pennsylvania have been reflected in the unparalleled progress made during the year on both these public projects.

The Commission reorganized March 18, 1924, at its offices in the Woolworth Building, New York City, with the re-election of Theodore Boettger, of Hackensack, as Chairman, and John B. Kates, of Collingswood, as Vice-Chairman, and the appointment of John C. McEnroe, of Newark, as Secretary. On February 19, 1924, Hon. James W. McCarthy, of Jersey City, was appointed as Counsel to the Commission and upon his resignation on July 8, 1924, Hon. Robert Carey, of Jersey City, was selected as his successor. Hon. Emerson L. Richards, of Atlantic City, continued to serve the Commission in an advisory capacity as Counsel, gratuitously.

The Commission held twenty-four (24) stated meetings during the year, all of which were open to the public and were devoted exclusively to tunnel matters. In addition to this the Commission participated in several public conferences in Jersey City and elsewhere dealing with various problems which arose from time to time. Before referring to the unprecedented success of the year 1924, the Commission regretfully halts to record the sudden and unexpected death of Clifford Milburn Holland, Chief Engineer to the Commission, which occurred on October 27, 1924, and to which more detailed reference is made in another section of this report.

The actual progress, in tunnel construction, which is considered more in detail in the report of the Chief Engineer, attached herewith, brought the under-river tubes to junction, the north tunnel on October 29th, and the south tunnel on December 7th, thus breaking down the only barriers remaining between the New York and New Jersey tunnel headings. The tunnel shields in both instances came together with only a variance of the smallest fraction of an inch, a splendid testimony to the skill and accuracy and close co-operation of the Commission's engineers and the contractors' forces.

The year 1924 saw the completion of the sinking of the seventh ventilation shaft, the completion of excavation for the under-river tunnel, the major portion of the erection of the iron lining, and placing of concrete lining and tunnel construction in open cut for the subway section of the New York approaches.

CONSTRUCTION OPERATIONS

Since the Commission's last report construction operations on Contracts Nos. 3, 4 and 5 have progressed to such a point that the contractors are now engaged in putting on the finishing touches so that the work will fit into the program outlined for the ensuing year. Contracts Nos. 3 and 4 are for the major portion of the under-river work and represent about one-half of the cost of the entire project. With the speedy prosecution of this work and the final development of plaza plans by the Commissions, the awarding of two additional major contracts was possible during the year. These are Contracts Nos. 5A and 6, actual operations under which have been begun. Contract No. 5A is for the completion of the New York Approach, while Contract No. 6 includes part tunnel work and the building of the approach on the New Jersey side. Bids for these contracts were opened on November 12, 1924, and were as follows:

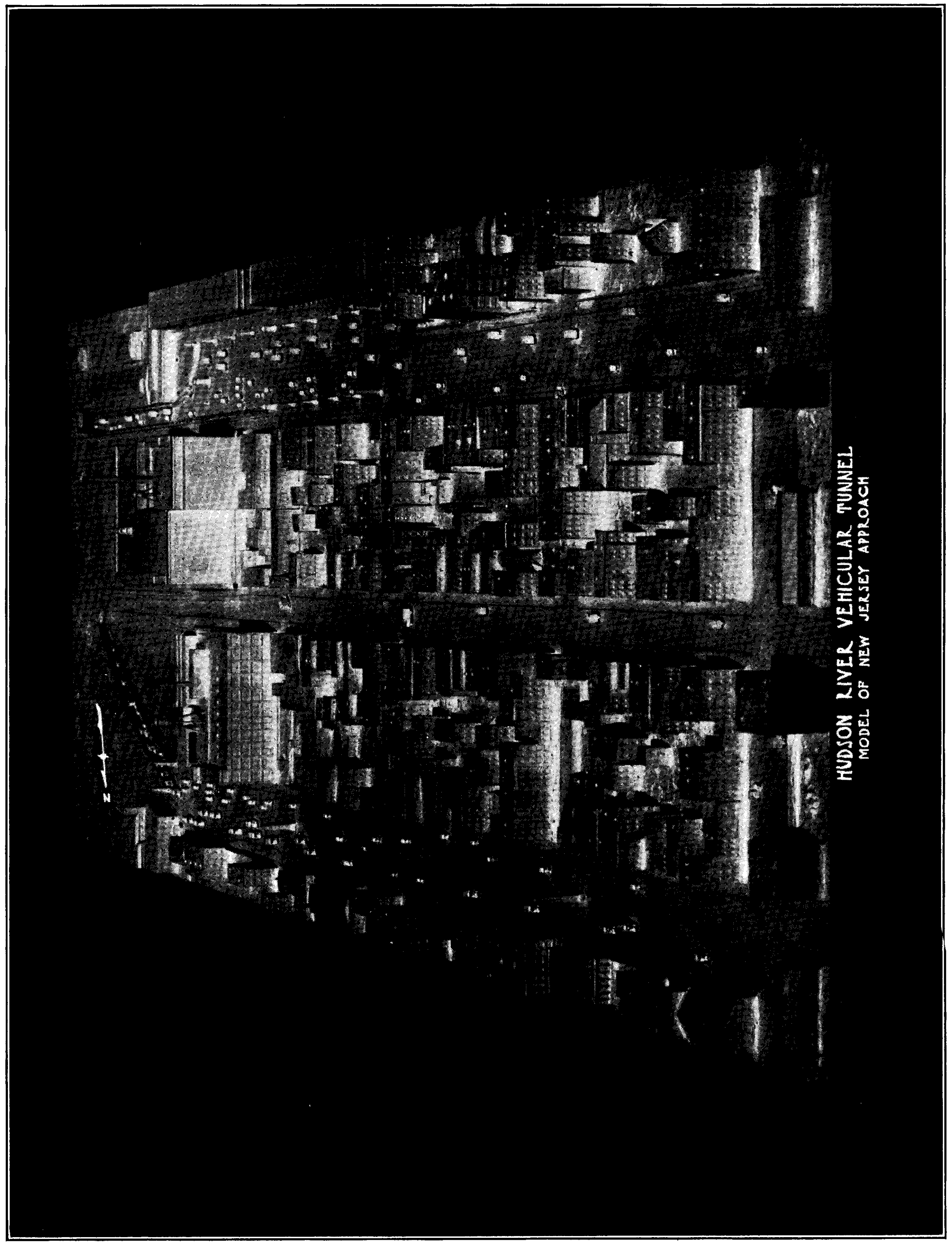
CONTRACT NO. 5A

Name and Address of Contractor	*Amount of Bid*
Rodgers & Hagerty, Inc., 70 East 45th St., New York City.	$301,312.25
Moranti & Raymond, Inc., 17 West 42d St., New York City.	$429,591.00
Frederick L. Cranford, Inc., 149 Remsen St., Brooklyn N. Y.	$465,591.00

CONTRACT NO. 6

Booth & Flinn, Ltd., 17 Battery Place, New York City, N. Y.	$2,582,969.75
Rodgers & Hagerty, Inc., 70 East 45th St., New York City, N. Y.	$2,706,365.00
Frederick L. Cranford, Inc., 149 Remsen St., Brooklyn, N. Y.	$4,262,462.00
Frederick Share Corp., 114 Liberty St., New York City, N. Y.	$4,467,890.50

It will be noted that the uncertainty that attends the planning and conduct of large public works continues to exist as indicated by the wide range in the bidding on both contracts, but it is a source of satisfaction to the Commission that the lowest bidder for each contract proposed to do the work for a figure less than was estimated by the Commission's Engineer. Contract No. 5A was awarded to Rodgers & Hagerty, Inc., at its figure of $301,312.25, and Contract No. 6 to Booth & Flinn, Ltd., at its figure of $2,582,969.75. Another source



HUDSON RIVER VEHICULAR TUNNEL
MODEL OF NEW JERSEY APPROACH

of satisfaction to the Commission was the fact that the successful bidders for these two contracts were the same contractors now engaged on Contracts Nos. 3, 4 and 5. Planning and preparation for future contracts have kept abreast of the actual construction operations so that before many months of the new year have passed the Commission will be in a position to make final strides toward the completion of its task.

REAL ESTATE AND PLAZAS

Many of the difficulties which confronted the Commission in 1923, with relation to the acquisition of property and the carrying out of the enlarged plaza plans, were brought nearer to adjustment. The action of the Legislature in the 1924 session, passing an act settling the question as to where the responsibility of the New Jersey State Highway Commission with its proposed roadway to Jersey Avenue, Jersey City, leading to the tunnels should end and the responsibility of this Commission with its plaza development leading to the tunnel portals should begin. It enabled the Commision to push forward its plaza plans so that all that remained was the acquiring of the necessary properties for the widening of 12th and 14th Streets and Jersey Avenue. In this connection the Commission had plaster models made showing the proposed transformation that will come with the laying out of the tunnel plazas in Jersey City. The Commission on March 18, 1924, also authorized the preparation of condemnation maps for the acquisition of all property included in the plaza zone. At this time the Commission anticipates no serious difficulty in obtaining the necessary properties for the plaza development.

There is pending before the Jersey City Commission a series of ordinances affecting the vacation of 11th Street, Jersey City, and certain changes of grades of other streets and the relocation, if necessary, of any type of public facilities. These ordinances have an important bearing upon the plaza development. Assurance has been given the Commission that the ordinances will be favorably acted upon, in which event another obstacle will be eliminated.

With the awarding of the two latest contracts it became necessary for the Commission to inaugurate plans for the acquisition of certain lands and easements in Jersey City and New York. Accordingly, under authority of Chapter 295, of the Laws of 1920, condemnation proceedings were begun December 9th, involving all property that it will be necessary to acquire from the Delaware, Lackawanna & Western Railroad Company, together with certain holdings of other Jersey City property owners. The institution of these proceedings will not prevent the Commission from entering into negotiations with property owners aiming at amicable adjustments. On November 12th, the Commission entered into an agreement with the Delaware, Lackawanna & Western Railroad Company, for the removal of tracks in its yard to make way for operations on Contract No. 6. The consideration in this agreement was $14,000, one-half of which was paid by New Jersey. Co-operating with the New York Commission, this Commission has complied with all of the requirements for similar proceedings on all of the property that will be needed in New York City.

As a part of its course with regard to the New York property the Commission authorized two agreements with the Board of Estimate and Apportionment of New York City, dated November 25th, providing for changes in grades of certain streets adjacent to the tunnel portals in New York City. These agreements entail an outlay of $33,000, one-half of which will be borne by the State of New Jersey.

ERIE AGREEMENT

By a further amendment of the agreement between the Commission and the Erie Railroad Company and The Long Dock Company the Commission was relieved of a costly part of construction work that would have been necessary under the terms of the original compact. This had to do with maintaining a tunnel structure sufficient to support the column footings of a five story warehouse which the Erie Railroad proposed to erect immediately over the tunnel shafts. The railroad company agreed to an alteration in its plans so that the proposed structure will be erected further westward from the tunnel bulkhead. In consideration of this relief the Commission agreed to pay its one-half share of $138,475 to the railroad company.

ORGANIZATION

On November 25th, the Commission named Milton H. Freeman, of Valhalla, New York, as Chief Engineer, to fill the vacancy caused by the death of Mr. Holland. Mr. Freeman had been Construction Engineer under Mr. Holland, and as such was next in command to Mr. Holland. His ability as a tunnel engineer had been attested by Mr. Holland and his experience made him an admirable selection by the Commission to asssume the duties of Chief Engineer.

CLIFFORD MILBURN HOLLAND

On the eve of the accomplishment of his greatest problem, Clifford Milburn Holland, Chief Engineer to the Commission, died at Battle Creek Sanitarium, Battle Creek, Michigan, whither he had gone in quest of health. On the very day that his body was borne to his home, there came a demonstration of his engineering skill and accuracy in the successful junction of the under-river headings of the north tunnel. Although a severe loss to the States of New Jersey and New York, as well as to the engineering world, the death of Mr. Holland served to emphasize the completeness with which he had organized the work and his staff of assistants. On October 29th, at a joint meeting of the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission, the following resolution was adopted:

Clifford Milburn Holland, Chief Engineer of the New York and New Jersey Tunnel Commissions, departed this life October 27th, 1924. His

association with the building of the Vehicular Tunnel covered its history from the first planning through the period of construction to the time of his death.

With wide experience in previous tunnel building, with vision to see and courage to do, he was clearly marked at the outset as the one outstanding man who should be called to plan and execute this, the greatest of tunnels. The successful completion of practically all the more difficult portions and the admirable planning of every detail of the remainder attests the wisdom of his choice as Chief Engineer.

In his zeal in planning and executing this great undertaking he gave himself so unstintingly to the work that he literally gave his life to it. Still a young man in years, destined to achieve even greater fame in his profession, his untimely death is a tragedy that shocks the members of this Commission while its pathos profoundly stirs our hearts.

The members of the New York State Bridge and Tunnel Commission and New Jersey Interstate Bridge and Tunnel Commission are deeply sensible of their personal loss and the loss to this great project. It is appropriate that the Commission should record in permanent form their estimation of the great service of Clifford Milburn Holland and their appreciation of him as engineer, associate and friend.

Resolved, That the foregoing expression be placed in full upon the permanent records of the Commissions and an engrossed copy be sent to the family, with a suitable expression of our sincere sympathy.

THE HOLLAND TUNNEL

Responding to a public demand as reflected in comment by the public press, as well as by resolutions of public and private bodies and expressions from leading citizens, the Commission on November 12th, adopted the following resolution:

WHEREAS, The untimely death on October 27, 1924, of Clifford M. Holland, Chief Engineer, in the construction of the Hudson River Vehicular Tunnel, has caused a general expression of sorrow; and

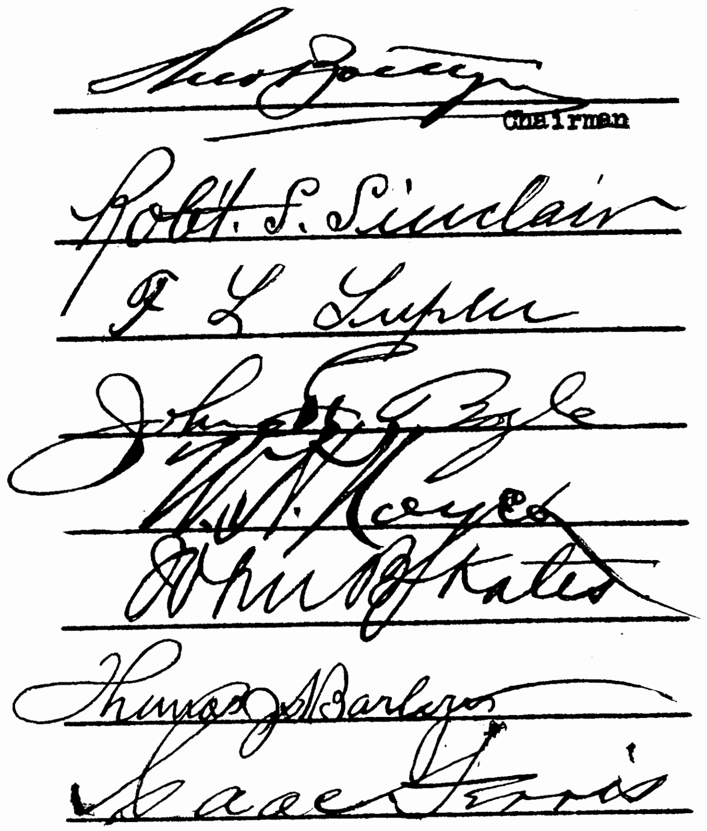
WHEREAS, By comment in the public press as well as by resolutions of public bodies and societies and expressions from leading citizens and civic organizations, the opinion is general that Mr. Holland gave his life to the work of the planning and construction of this great public utility; and

WHEREAS, The members of the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission are in accord with the widespread suggestion that some fitting tribute be paid to the memory of the deceased engineer; therefore be it

Resolved, That the Hudson River Vehicular Tunnel, now being constructed between Canal and Broome Streets, in the Borough of Manhattan, City of New York, and 12th and 14th Streets, Jersey City, New Jersey, be and it is hereby dedicated to the memory of Clifford Milburn Holland, and that the said Hudson River Vehicular Tunnel is hereby designated and named as "The Holland Tunnel."

$8,000,000 BOND ISSUE

The Commission here records its gratification over the overwhelming public support of the tunnel project in the State of New Jersey as demonstrated in the adoption on November 4th, at the general election, of the referendum authorizing the issuance of $8,000,000 of State Highway Extension Bonds. Of this sum it is estimated that $7,000,000 will be required for the completion of the tunnel project; the remaining $1,000,000 is to be devoted to the Delaware River Bridge project.



NEW YORK STATE BRIDGE AND TUNNEL COMMISSION

AND

NEW JERSEY INTERSTATE BRIDGE AND TUNNEL COMMISSION

REPORT OF CHIEF ENGINEER

DECEMBER 31, 1924

LIST OF PLATES

December 31, 1924.

REPORT OF CHIEF ENGINEER

New York State Bridge and Tunnel Commission and New Jersey Interstate Bridge and Tunnel Commission:

GENTLEMEN—I submit herewith a report for the year ending December 31, 1924, the major portion of which was under the supervision of Mr. Holland.

The work of the year 1923 was marked by a program of shaft sinking and the commencement of shield driving. By the end of that year, six of the seven ventilation shafts had been sunk to grade and the seventh nearly completed. Five of the six shields were in operation and the work of actual tunnelling under the river was in full progress.

The year 1924 has been marked by a program of shield driving, which completed the excavation of the under river tunnels; by the practical completion of the tunnel in Spring St. and the greater part of the tunnel in Canal St. of the New York Approach Section; and by the preparation and award of contracts for the remaining approach sections, thereby completing the award of all work for the tunnel structure proper.

The river shields of the North Tunnel, one driven westward from New York and one driven eastward from New Jersey, met on November 18, 1924. Corresponding shields in the South Tunnel were 2.2 feet apart on December 31, 1924, and will be brought together early in 1925. This completes all mid-river excavation and metal tunnel lining, except the junction rings to be erected after the shields are dismantled; this dismantling is 75% completed in the North Tunnel and will be started immediately after the shields are brought together in the South Tunnel. Excavation in rock for the sump and pump chamber between the two tunnels at their lowest point is 95% completed.

Excavation of the South Tunnel west of the New Jersey Land Shaft was completed April 2, 1924, the shield dismantled and the metal lining built to the end of the Contract. The equipment of this shield was, upon removal, installed in the shield for driving the North Tunnel west from the New Jersey Land Shaft. This latter shield, the largest subaqueous shield driven, with an outside diameter of 31′ 00″ was started in July, and it is expected that the excavation in this tunnel will be completed early in February, 1925.

The outstanding feature of shield driving has been the rapid progress attained through Hudson River silt. A maximum of 1022.7 ft. was driven in one calendar month, 510 ft. in the North Tunnel and 512.7 ft. in the South Tunnel. This was made possible through methods devised for controlling the exact amount of material taken into the tunnel and the temporary storing of this material in the tunnel immediately back of the shield.

The surveys, upon which the alignment of the tunnel depended, checked very closely and approaching river shields have been brought to an exact junction.

The placing of the concrete lining which forms the tunnel roadway and ventilation ducts was commenced in May and in addition to completing the concrete in a short section of tunnel a method has been worked out that will insure rapid progress in 1925. This work is done in normal air after the metal lining has been thoroughly cleaned, bolts tightened, and the structure made watertight.

In 1923, excavation had been well advanced in the North Tunnel of the New York Approach Section—Contract No. 5. During 1924, all excavation under this contract has been completed which includes excavation in the South Tunnel in Canal St., and for the ventilation building to be erected on Washington St. between Canal and Spring Sts. This work has been successfully accomplished through carefully worked out methods to overcome the difficulties arising from the presence of fine sand with ground water and, in the case of the South Tunnel, the close proximity of the Canal St. Sewer. The multiplicity of sub-surface, surface and overhead structures in the streets has required great care in the prosecution of the work to keep these services in continuous operation. The North Tunnel is practically finished and the South Tunnel about 80% completed.

Contracts and specifications were prepared for the Open Approach in New York, Contract No. 5A, and the Approach Section in New Jersey, Contract No. 6. Bids were received on November 12 and these contracts were awarded to the low bidders, Rodgers & Hagerty, Inc., and Booth & Flinn, Ltd., respectively. Finish and equipment contracts are now in course of preparation.

The success attained last year in holding to a minimum the hazards of compressed air work has been continued throughout 1924. Compressed air work is now practically completed on this project and the fact that there has not been a single fatality from this cause during the entire job is evidence of the precautions that have been taken to prevent compressed air illness. During 1924 there was one fatal accident, several of the workmen have been painfully injured and a number have suffered minor injuries. These accidents are much to be regretted, but they have occurred in spite of careful attention and supervision. The ever varying conditions, under which the work is conducted, make it difficult to install standard safeguards for the protection of the workmen. Those in charge of the work have been keenly alive to the situation and every feasible precaution has been taken and every inducement offered to reduce the hazards of an undertaking of this character and magnitude.

CONTRACT PROGRESS

On the New York side of the Hudson River both shields driven westward from the land shafts were on January 1, 1924, practically ready to enter the river shafts. These shields passed through the New York River Shaft during the early part of the year and have continued through earth and rock excavation to the junction point with the shields coming from New Jersey. On the New Jersey side of the river the shield in the North Tunnel, which at the beginning of the year had passed through the North River Shaft, continued on its way across the river to a junction with the New York shield. These headings were holed through on October 29 in a rock drift when the shields were 56.3 ft. apart. (Plate No. 1) Tunneling operations were then conducted from the New York River Shaft, all excavation being completed on November 13, 1924, and on December 31, all iron erected, with the exception of seven junction rings. On Wednesday, December 17, compressed air was removed from this tunnel, and the balance of the work is to be conducted in normal air. The shield in the New Jersey South Tunnel East, at the beginning of the year, had been driven 433 ft. eastward from the South Land Shaft. During the year it continued on to the River Shaft and after passing through that structure it was advanced under the Hudson River to a junction with the New York shield. Excavation was holed through in a rock drift in this tunnel on December 7, similar to the method followed in the North Tunnel. On December 31 the shields in this tunnel were 2.2 ft. apart. Shield junction will be made and compressed air removed in the early part of 1925. The New Jersey South Tunnel West, at the beginning

PLATE No. 1—Holing Through, North Tunnel.

of the year, had reached a point 229 ft. west of the Land Shaft and during the year was driven 652 feet to the end of the Contract. The shield has been dismantled and the iron lining completed. In July the shield for the North Tunnel West in New Jersey was erected in the North Land Shaft. This tunnel is 30′ 4″ in outside diameter, 10 inches larger than the other river tunnels, and the largest shield-driven subaqueous tunnel built to date. It was advanced through the west wall of the shaft and has progressed 610 ft., leaving 172 ft. of excavation to be made before reaching the contract limit. It is anticipated this work will be finished in February, 1925, which will complete all shield driving.

On the New York Approach Section under Contract No. 5 the North Tunnel extends in cut and cover construction from the Spring St. Shaft to the northerly side of Dominick St. At the beginning of the year, about 60% of the excavation had been completed. During 1924 the remaining excavation was completed and a concrete steel tunnel of rectangular section built. The South Tunnel traverses Canal St. in cut and cover construction from the Canal St Shaft to the easterly line of Hudson St. During the year excavation in this section has been completed, all structural steel erected and 50% of the concrete placed.

During 1924, contract plans and specifications for Contract No. 5A, the Open Approach Sections in Manhattan, were completed and advertised for proposals. On November 12, 1924, bids were received and on November 25, 1924, the Commissions awarded the contract to the low bidder, Rodgers & Hagerty, Inc. All of the bids are appended hereto. (Plate No. 16.) Work was started on December 24, 1924. This contract begins at the easterly end of Contract No. 5. The southern portion consists of a reinforced concrete structure in open cut proceeding from the east side of Hudson St. to grade at the corner of Canal, Varick and Vestry Sts. The northern portion begins on the northerly side of Dominick St. and, passing under Dominick St., proceeds in open cut to grade on the northerly side of Broome St. The limits of this contract are shown on plan and profile. (Plate No. 3.)

During the year contract plans and specifications for Contract No. 6, which includes the construction of two Open Cut Sections and the Open Approaches in New Jersey, were completed and advertised for proposals. On November 12, bids were received, and on November 25 the Commissions awarded the contract to the low bidders, Booth & Flinn, Ltd. All of the bids received are appended hereto. (Plate No. 17.) Work on this contract was started December 22, 1924. This contract begins at the westerly end of the shield driven tunnel work under Contract No. 4 and extends westerly under the Erie R. R. and D. L. & W. R. R. yards to the portals and thence in open cut to street grade, the North Tunnel at Provost St. and 14th St. and the South tunnel at Provost St. and 12th St. The limits of this contract are shown in plan and profile. (Plate No. 3.)

Detailed features of contract work are described under the different contracts.

Contract No. 3

Contractor	Booth & Flinn, Limited
Date of Contract	March 28, 1922
Contract time	Three years
Contract bid price	$7,199,623.00
Estimated value of contract to date	$7,086,784.72
Total amount certified to date for payment	$6,586,784.72
Total amount of retained percentage	$500,000.00

This contract embraces a 2,000 ft. section of twin tunnels between the New York Land Shafts and a point about 600 ft. west of the New York pierhead line and the construction of the ventilation shaft near the New York pierhead line. See plate No. 3.

RIVER SHAFT CAISSON

At the beginning of 1924, the caisson had been sunk to position but had not been sealed to the rock. Both shields from the eastward were practically ready to enter this shaft. The work of sealing the caisson and waterproofing it was done in the following manner:

The North Tunnel Shield was advanced to within 14 ft. of the caisson. Shield driving was then suspended, a rock drift was driven to the caisson and a sump sunk against the side of the caisson to a point below the cutting edge. A 3″ pipe with slotted holes was imbedded in a trench located along the four sides of the working chamber of the caisson, just inside the cutting edge. All seepage was collected in this pipe and carried to the tunnel sump, from which it was pumped out. A 6″ layer of protection concrete was placed across the entire floor of the caisson. The diversion of the water made this layer absolutely dry so that the waterproofing could be placed in low air pressure necessary to dry condensation and the concrete invert placed in free air. The ply waterproofing was applied in the usual manner and covered with a brick protection. For the purpose of concreting, the caisson invert was divided into four sections by vertical bulkheads and the concrete was poured from a mixing plant on the surface one section at a time. After the concrete had obtained sufficient strength, the pipe and drain were grouted solid from the North Tunnel sump. Later the space between the rock and the sides of the caisson was grouted, leaving a perfectly dry seal.

TUNNELING

After the river caisson was sealed to the rock and waterproofed, the roof of the working chamber was raised to the upper position over the tunnel chamber and compressed air was applied. The east and west shield bulkheads in both the North and South Tunnel chambers were burned out and both shields were driven through the caisson. A timber and concrete cradle of sufficient strength to carry the shield was erected in each chamber and the shield jacked across the caisson. Temporary rings of iron were erected through the shaft against which the shield jacks reacted. The North Tunnel was driven 144 feet and the South Tunnel 154 feet west of the River Shaft with the deck of the caisson still in position, but the excavated material and iron lining were handled through the tunnels back to the Land Shafts, thus eliminating the use of caisson locks to serve shield driving with the attendant slow progress.

After the shields had progressed a sufficient distance west of the River Shaft to permit tunnel bulkheads, these were built in each tunnel and placed in operation. The air pressure was removed from the caisson and the tunnels east of the shaft, the caisson roof removed and head frames and cages installed. After this all tunneling operations were carried on from the River Shaft, which released the tunnels between the Land and River Shafts for the placing of concrete lining. The material encountered in shield driving was mixed face, that is, part rock and part soft ground, for the entire distance to the end of the contract, except about 200 feet in each tunnel where the headings were in a full face of rock. The excavation in part earth and part rock was carried on by driving a short bottom drift in advance of

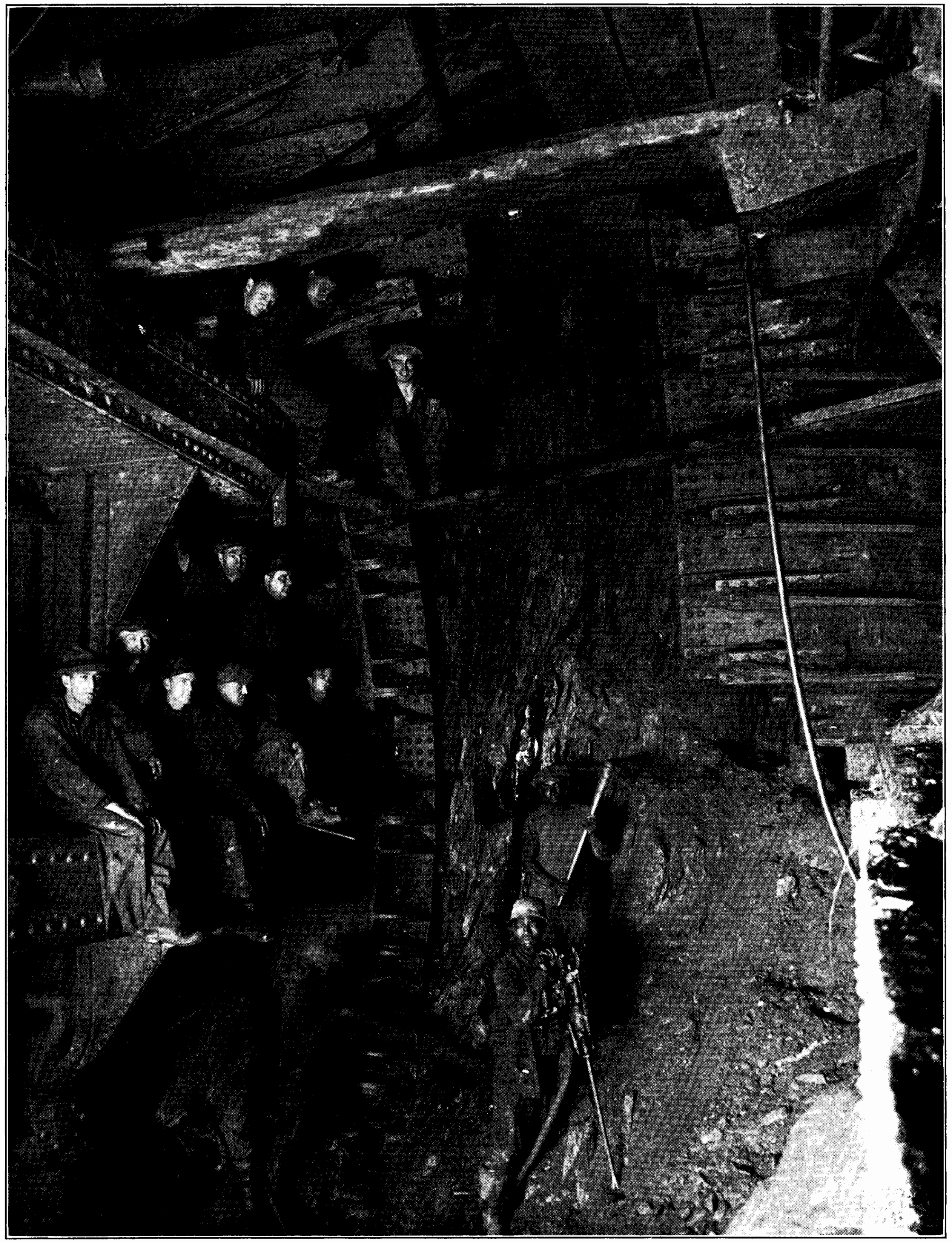


PLATE No. 2—Shields Approaching Junction, North Tunnel.

the shield in which was placed a concrete cradle to support the shield. The remaining rock was blasted away for the length of one shove and the soft ground in the top was excavated, and the face protected by breast boards and the top by poling boards. This method was changed after the shield had progressed about 130 feet west of the shaft, the bottom heading or drift being eliminated. The rock was blasted out for the length of the shove, the bottom trimmed to the shape of the tunnel and a cradle of bagged concrete placed in front of the shield. The method of excavating the top in soft ground remained the same. The space between the rock and iron lining was grouted solid after the passage of the shield.

On October 22, 1924, shield driving was suspended in the North Tunnel and a bottom heading or junction drift was started to meet a corresponding drift from the New Jersey heading. This drift was driven westward for about 50 feet and on October 29, at 1.30 p. m., the rock barrier remaining between this heading and the North Tunnel heading coming from New Jersey was blasted away. After this, all tunneling operations were conducted from the New York side of the river as the junction was much nearer the New York shaft. A concrete cradle, with steel rails embedded for the shield to slide upon, was placed in the drift, the remaining section was excavated and the New York shield was pushed forward to a junction with the New Jersey shield. The hoods and cutting edges of both shields were burned away and the steel skins of the two shields were advanced to contact with each other. The shields have been 75% dismantled and seven rings remain to be erected to complete the junction between the two sections and to make the lining continuous under the river. On December 17, compressed air was removed from the junction chamber. It was replaced on December 26, to make certain pipe connections with the sump, but will be again removed shortly after January 1, 1925, and thereafter operations will be carried on in normal air.

On December 3, 1924, work was suspended in driving the South Tunnel shield and a junction drift started. This was driven westward about 40 feet and on December 7, 1924, at 5.30 a. m., the rock barrier was blasted away and this heading connected with the New Jersey heading. Work on the New York side was suspended and the New Jersey shield has been driven to meet the New York shield. At the end of the year, these shields were 2.2 feet apart. Excavation for the sump and pump chamber in the rock between the two tunnels west of the River Shaft is practically completed. The waterproofing, concreting and iron lining of this sump will be finished early in 1925.

CONCRETING

In July, 1924, the placing of the concrete lining forming the roadway and air ducts was started in the North and South Tunnels between the Land and River Shafts. (Plate No. 4.) The iron was recaulked and leaking bolts made dry well ahead of the concrete work, great care being taken to insure watertightness of the tunnel before placing concrete. The concrete invert was first placed in both tunnels from Land Shafts to the River Shaft. The remaining concrete was then poured in nine operations; collapsible steel forms in 60 ft. sections, supported and moved by carriages resting on previously placed concrete, were used. The exposed surfaces of the air ducts have been finished so as to present a smooth surface to the flow of air and exposed surfaces in the tunnel roadway have been finished to smooth, even appearance.

At the close of the year the concrete lining between the Land Shafts and the River Shaft in both tunnels is about 85% completed. No concreting has been done west of the River Shaft.

CONTRACTOR'S PLANT

During the year the Contractor has moved his head frames and cages from the Land Shafts to the River Shaft and has dismantled the gantry on Spring St. and about 50% of the gantry on Canal St. A central concrete mixing plant has been installed in the River Shaft Caisson and all the concrete for the tunnels is mixed at this plant. The pipe lines carrying the air pressure and hydraulic pressure from the power house to the headings have been removed from the land tunnels and have been carried over the Canal St. gantry and Pier 35, and down the River Shaft to the headings.

CONTRACT NO. 4

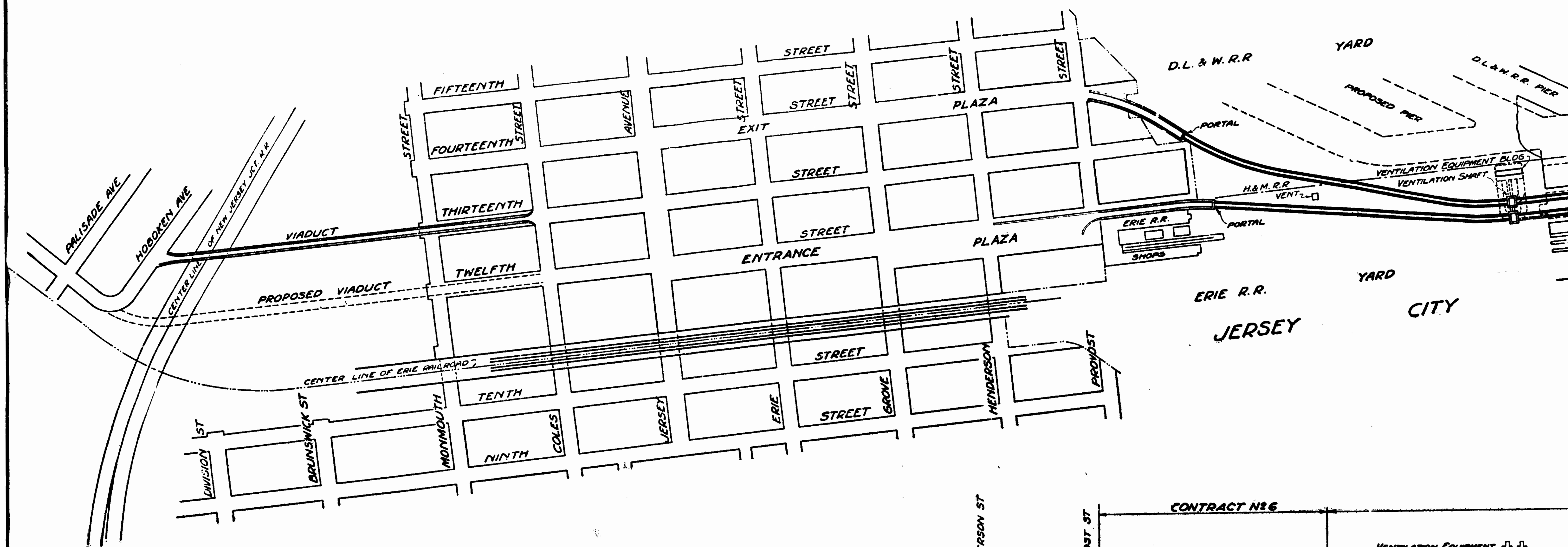
Contractor	Booth & Flinn, Limited
Date of Contract	March 28, 1922
Contract Time	Three years
Contract Bid Price	$12,132,100.50
Estimated Value of Contract to Date	$10,574,057.78
Total amount certified to date for payment	$10,074,057.78
Total amount of retained percentage	$ 500,000.00

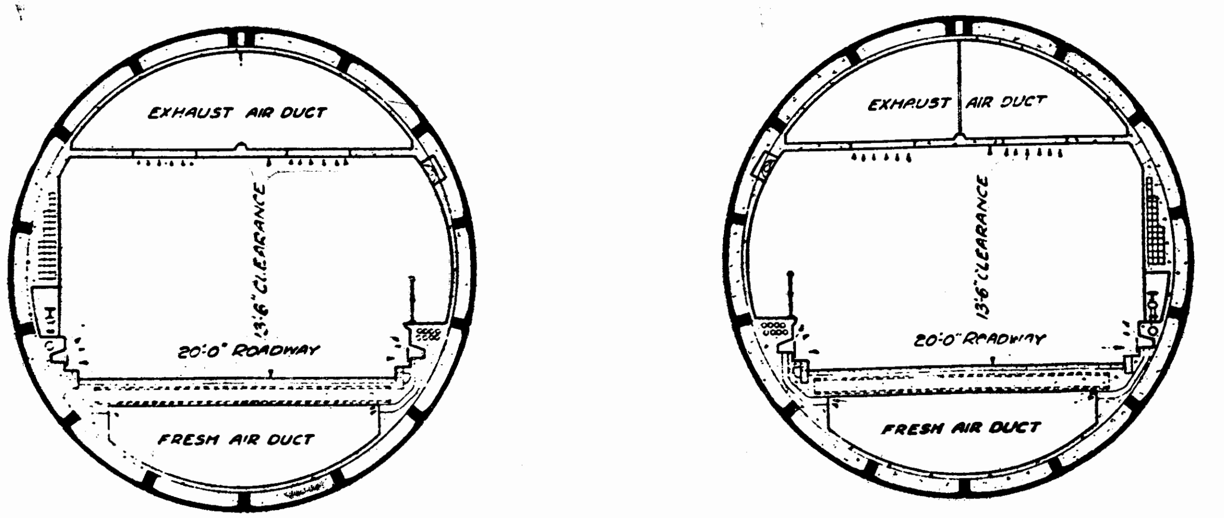
This contract provides for the construction of twin tunnels between a point about 600 feet west of the New York Pierhead Line and a point approximately 1000 feet west of the New Jersey Bulkhead Line, the construction of two land shafts and two river shafts.

All shafts were sunk to grade and completed in 1923, except the South River Shaft which was not finished until June 23, 1924.

TUNNELING

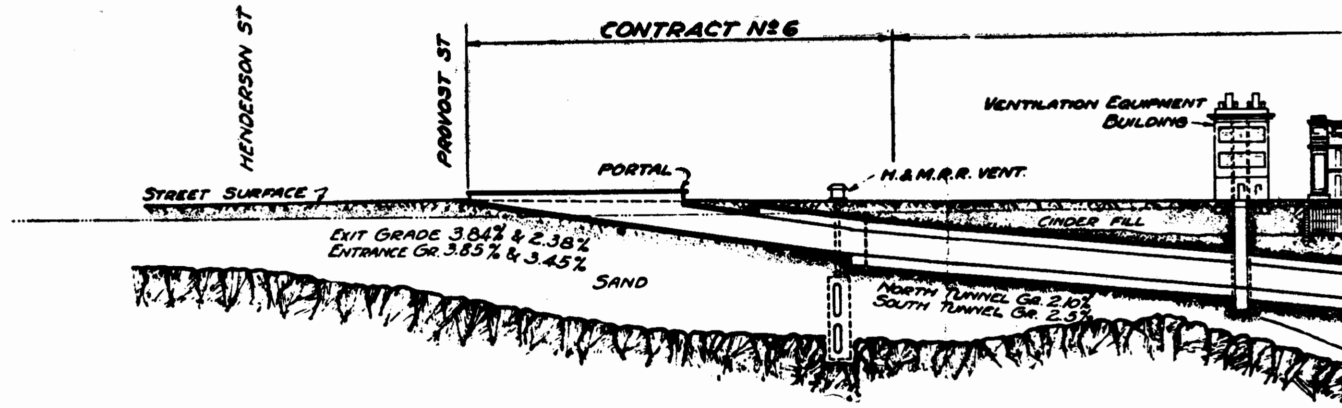
All shields were built in the Land Shafts. The north shield east and the south shield west were built first and started out from their respective caissons. When the south shield west had advanced 159 ft. west of the Land Shaft it was stopped and the south shield east erected and started from the shaft. By this time the north shield east had progressed 346 ft. and from here on this shield was ahead of the south shield east by distances varying from 346 ft. to 1450 ft. After they had passed through the riprap crib, the present river bulkhead and soft mud, as described in last year's report, Hudson River silt was encountered. To hold the shield and tunnel to the proper grade, it was necessary to take in a certain amount of material through the shield. This method of control was further enhanced by depositing this material directly behind the shield. When the shield rose above grade, additional material was taken in, which relieved the lifting pressures in front of the shield and at the same time increased the amount of material deposited in the tunnel and accordingly the weight of the tunnel. When the shield settled below grade, less material was taken in, which increased the lifting pressure in front of the shield and at the same time lessened the weight in the tunnel. The four pockets of the shield immediately above the springing line were equipped with hydraulically operated doors through which the mate-

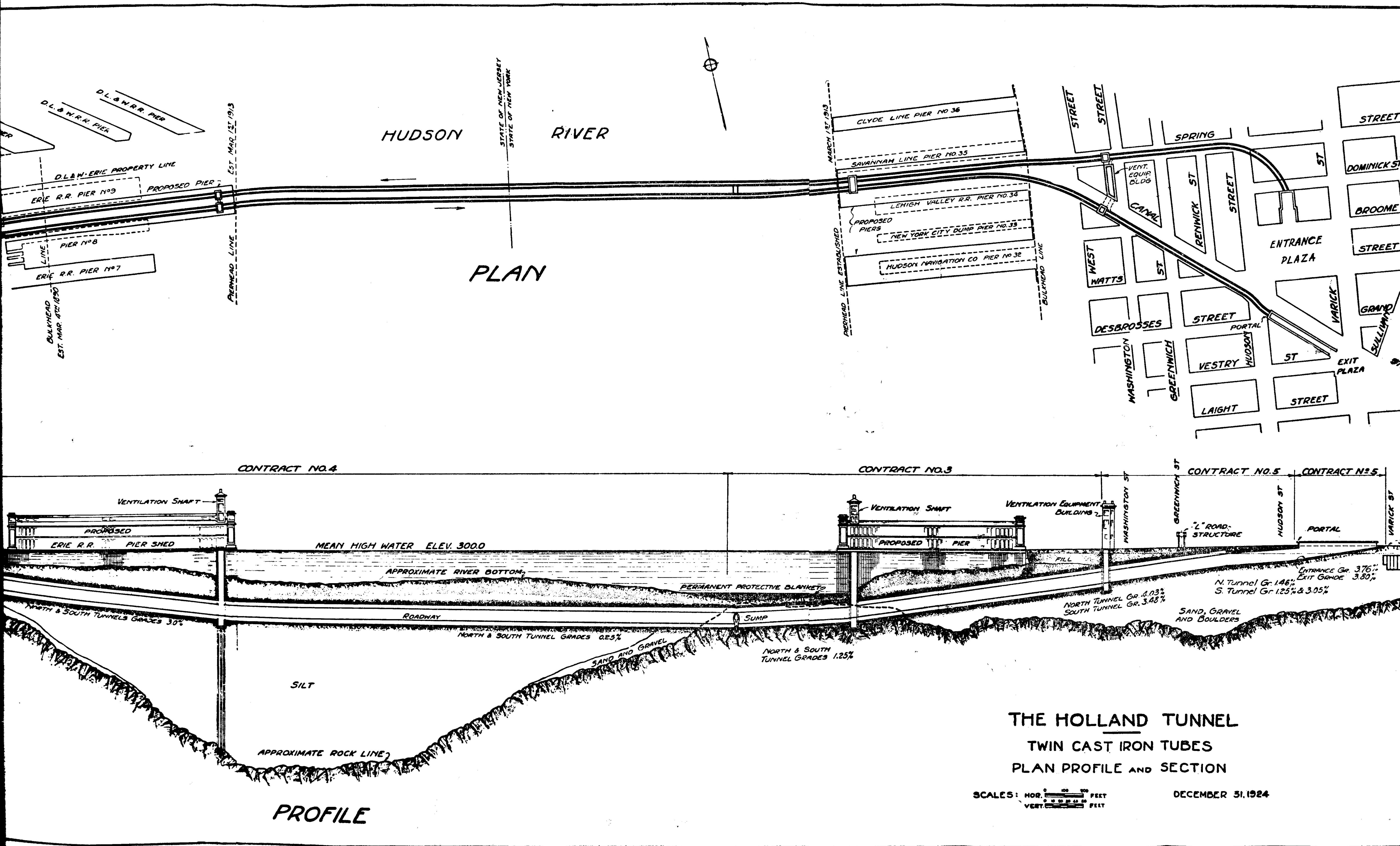


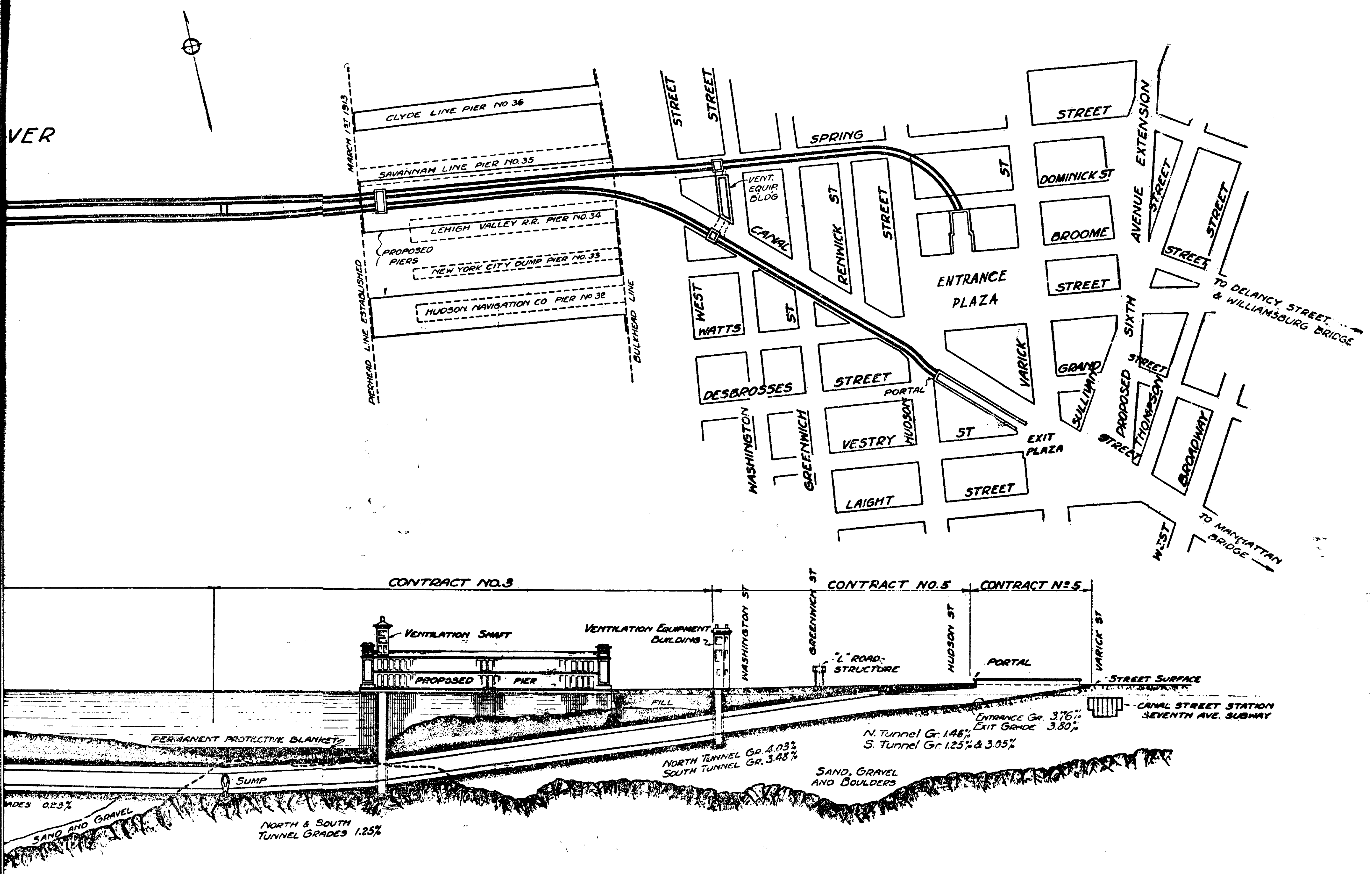


TYPICAL CROSS SECTION

SCALE FEET




HUDSON RIVER
PLAN
PROFILE
D.L.&W.R.R. PIER
D.L.&W.R.R. PIER
D.L.&W.-ERIE PROPERTY LINE
ERIE R.R. PIER No 9
PROPOSED PIER
PIER No 8
ERIE R.R. PIER No 7
BULKHEAD LINE EST. MAR. 4th 1890
PIERHEAD LINE EST. MAR. 1st 1913
STATE OF NEW JERSEY
STATE OF NEW YORK
CLYDE LINE PIER NO 36
SAVANNAH LINE PIER NO 35
LEHIGH VALLEY R.R. PIER NO 34
NEW YORK CITY DUMP PIER NO 33
HUDSON NAVIGATION CO PIER NO 32
PROPOSED PIERS
PIERHEAD LINE ESTABLISHED MARCH 1st 1913
BULKHEAD LINE
VENT. EQUIP. BLDG.
SPRING
DOMINICK ST
BROOME
STREET
CANAL
RENWICK ST
ENTRANCE PLAZA
WEST
WATTS ST
DESBROSSES
GRAND
SULLIVAN
VARICK
PORTAL
EXIT PLAZA
WASHINGTON
GREENWICH
VESTRY
HUDSON
LAIGHT
CONTRACT NO.4
CONTRACT NO.3
CONTRACT NO.5
CONTRACT No.5
VENTILATION SHAFT
VENTILATION EQUIPMENT BUILDING
WASHINGTON ST
GREENWICH ST
"L" ROAD STRUCTURE
HUDSON ST
PORTAL
VARICK ST
PROPOSED
ERIE R.R. PIER SHED
MEAN HIGH WATER ELEV. 300.0
PROPOSED PIER
FILL
APPROXIMATE RIVER BOTTOM
PERMANENT PROTECTIVE BLANKET
ROADWAY
SUMP
NORTH & SOUTH TUNNELS GRADES 3.0%
NORTH & SOUTH TUNNEL GRADES 0.25%
NORTH & SOUTH TUNNEL GRADES 1.25%
NORTH TUNNEL GR. 4.03%
SOUTH TUNNEL GR. 3.48%
N. Tunnel Gr. 1.46%
S. Tunnel Gr. 1.25% & 3.05%
ENTRANCE GR. 3.76%
EXIT GRADE 3.80%
SAND, GRAVEL AND BOULDERS
SAND AND GRAVEL
SILT
APPROXIMATE ROCK LINE
THE HOLLAND TUNNEL
TWIN CAST IRON TUBES
PLAN PROFILE AND SECTION
SCALES: HOR. FEET
VERT. FEET
DECEMBER 31, 1924



THE HOLLAND TUNNEL

TWIN CAST IRON TUBES

PLAN PROFILE AND SECTION

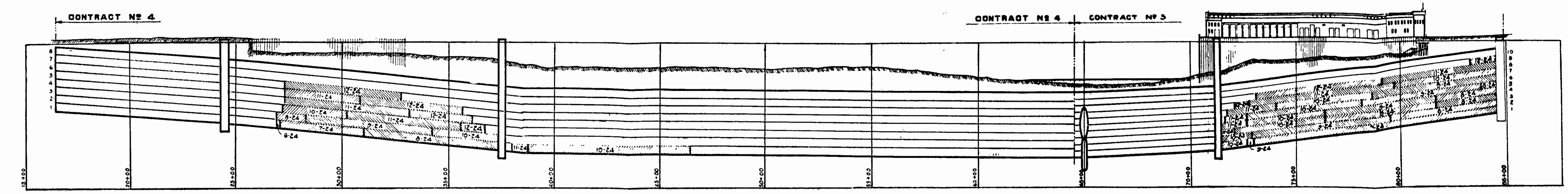
SCALES: HOR. 0 100 200 FEET
VERT. FEET

DECEMBER 31, 1924

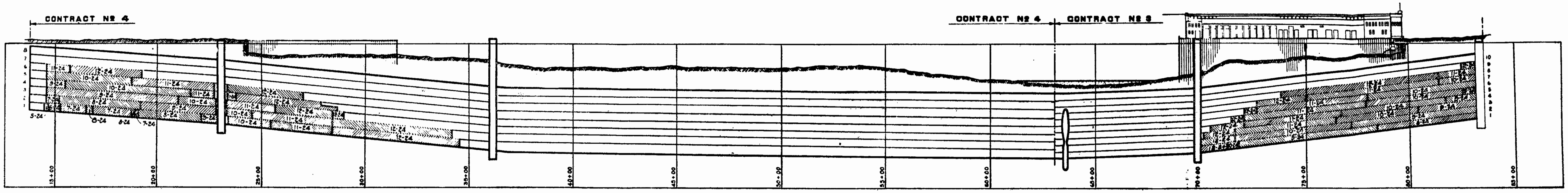
PLATE N

NEW JERSEY

NEW YORK



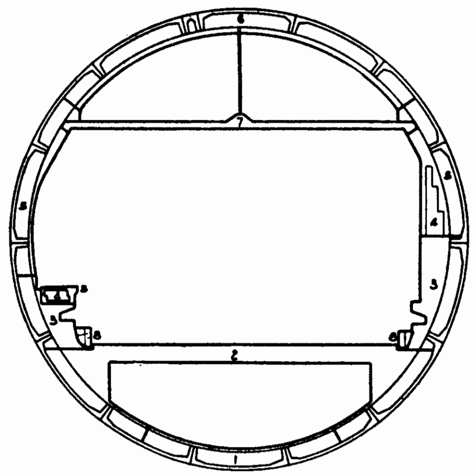
NORTH TUNNEL



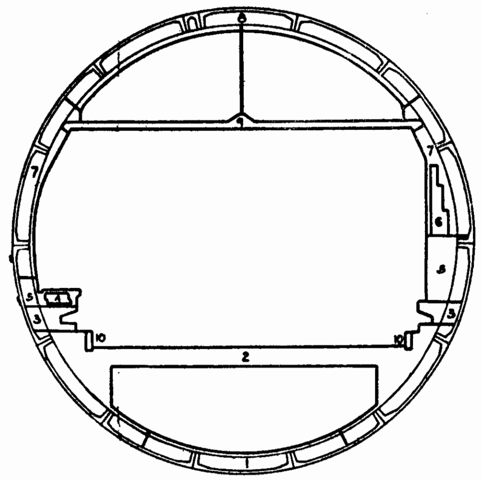
SOUTH TUNNEL

THE HOLLAND TUNNEL

CONTRACTS Nos. 3 AND 4
CONCRETE TUNNEL LINING
PROGRESS PROFILES



CONTRACT Nº 4
CONCRETING SCHEDULE



CONTRACT Nº 3
CONCRETING SCHEDULE

NEW YORK STATE
BRIDGE & TUNNEL COMMISS
AND
NEW JERSEY INTERSTATE
BRIDGE & TUNNEL COMMISS

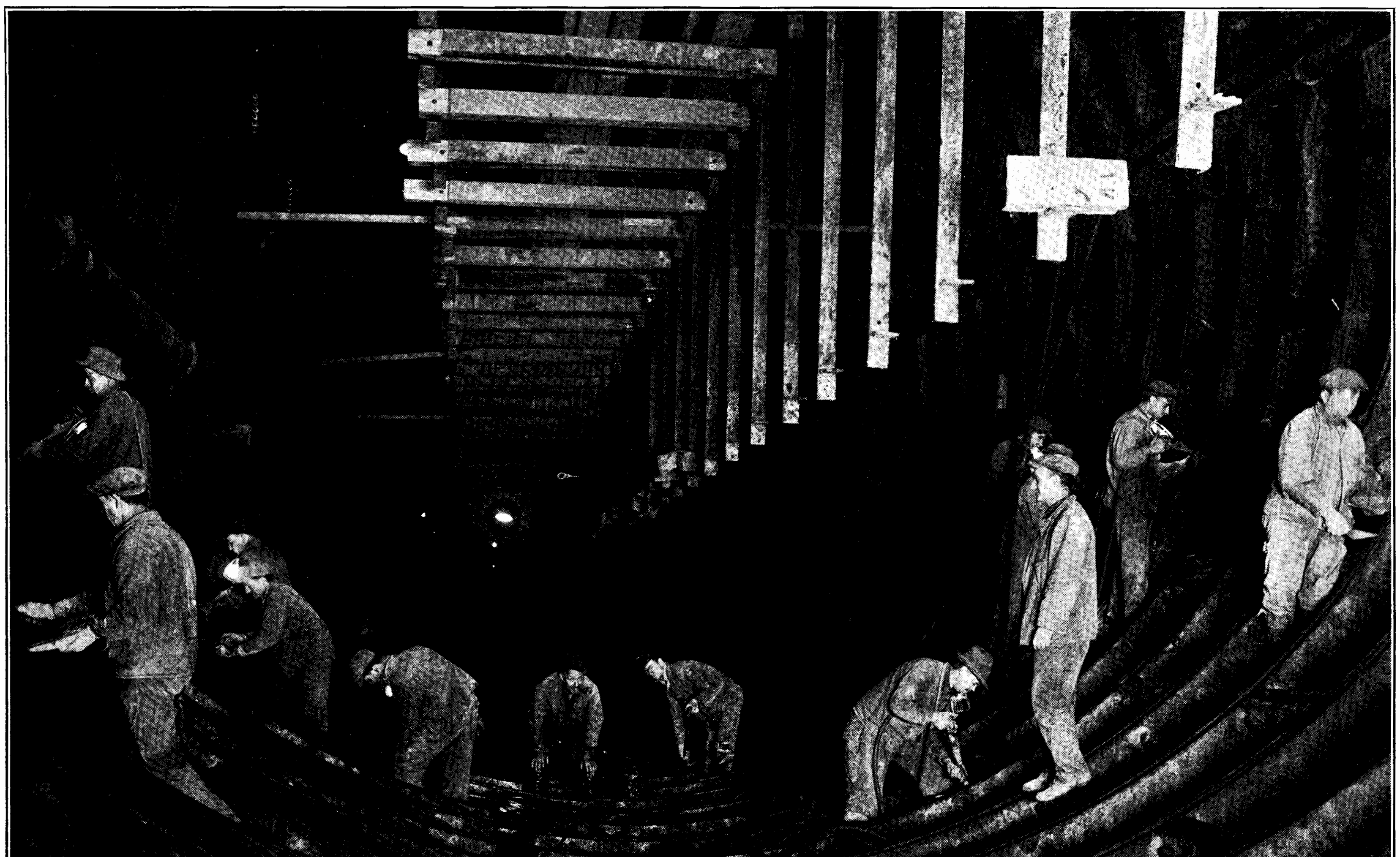


PLATE No. 5—Making Iron Invert Ready for Concreting.

PLATE No. 6—Partially Completed Tunnel Section, North Tunnel.
Contract No. 3.

PLATE No. 7—Shield Entering South River Shaft, New Jersey.

rial was admitted. This incoming silt was carried along a chute and deposited behind a trailing steel bulkhead following about ten feet behind the diaphragm of the shield. After the system had been fully worked out, it was found necessary to use only the two middle pockets. With the exception of the hydraulically operated doors, which could be closed at any time, the entire face of the shield was bulkheaded affording a great factor of safety and making it possible to drive the tunnel at a comparatively low air pressure, 21 lbs. or less.

The amount of material taken in through the shield varied from 10 yds. to 60 yds. per "shove" of 2½ ft. East of the River Shafts, 20 yds. per "shove" was about the average amount necessary to control the shield. Immediately behind the shield, the tunnel rose slightly, stopping about 50 ft. back. Thereafter, there was a tendency to settle accompanied by a shortening of the vertical diameter and a lengthening of the horizontal diameter. As a further means of control, after the shields had passed through the River Shafts, each was weighted with 100 tons of pig iron. This adjustable weight which could be put in or removed at will was another facility for keeping the shields to proper grade. The total weight of shield and pig iron was about 422 tons.

From the Land Shaft to a point east of the River Shaft, a distance of some 1300 feet, the tunnel is built on a 3% downgrade then on a 0.3% down grade a distance of 1600 ft. to the end of the contract. The latter grade made it necessary to drive the tunnel very close to theoretical grade so that there might be proper drainage but such excellent results were obtained that there will be no difficulty in this respect.

After the shields had passed through the River Shafts into more uniform material, the working force was reorganized for silt conditions resulting in a usual progress in each tunnel of 22½ ft. per 24 hr. day and a maximum of 25 ft. The highest monthly progress in the North Tunnel was 508 ft. in June and in the South Tunnel 535 ft. in July. The method of shield driving described above was worked out and put into operation by the late LeRoy Tallman, General Superintendent for the Contractor on Contract No. 4, the New Jersey River Section.

In passing from Rudson River silt into rock, a stratum of sand and gravel some 10 ft. thick was encountered overlying the rock. As the shield encountered points of rock the latter was excavated below the shield and the space filled with sand, so that the iron lining, after the passing of the shield, would not rest on these projecting points. When the approaching shields from New York and New Jersey had reached the point where only 60 ft. remained between cutting edges, a bottom junction drift was driven, connecting the two headings through which line and grade were checked. Shield junction was made as described under Contract No. 3.

No grout was used where the tunnels are in Hudson river silt, but in rock the space between the tunnel lining and the rock was filled with grout and in sand grout has been used to compact disturbed material.

For the first 50 ft. east of the Land Shafts, 150 ft. on both sides of the River Shafts and a 50-ft. section where the tunnel enters rock, the metal lining is of cast steel instead of cast iron, to provide a more rigid structure, at points of possible flexture.

Where the tunnels are in silt, no calking was done until after the compresed air had been removed. Where the tunnels are in rock or sand, the lower quarter was calked before the air was removed.

The material which was taken in through the shield and deposited in the tunnel was removed later in normal air by means of a clam shell bucket, operated by a motor suspended from a monorail in the top of the tunnel. This work was followed by cleaning and calking to prepare the tunnel for concrete.

In the tunnels driven westward from the Land Shafts, excavation was conducted in all the pockets of the shield above the springing line and the four immediately below the springing line. While the shields were passing through silt, the material flowed through the pockets into the tunnel as the shield advanced, but it was found necessary to excavate sand or other granular material in the pockets of the shield.

The South Shield West, which had been driven 229 feet from the Land Shaft on January 1, 1924, reached the end of the contract on April 2, 1924. This contract limit was shortened by 345 feet to avoid the possibility of setting up earth pressures in front of the shield that might disturb the shaft and tunnels of the Hudson and Manhattan Railroad Company. The remaining section will be built in open cut excavation. The shield was dismantled and the metal tunnel lining extended to the end of the contract.

After the South Tunnel West shield had reached the end of the Contract, the hydraulic equipment was removed and installed in the shield for the North Tunnel West. The starting of this shield from the shaft differed from the others in that the shield was not stopped to remove the decking from the caisson, install cages and erect a concrete bulkhead. After the shield was erected in the shaft and the decking placed in the upper position, the locks in the concrete bulkhead east of the shaft were reversed, permitting compressed air to be applied to the shield chamber. The material from this heading is handled through this tunnel bulkhead to the River Shaft. This shield, the erection of which was started in July, has been advanced through silt and sand excavation a distance of 610 feet, leaving 172 feet still to be driven before reaching the end of the contract.

CROSS PASSAGE BETWEEN THE NORTH AND SOUTH RIVER SHAFT CAISSONS

A cross passage 9′ 6″ in diameter was built between the North and South River Shaft Caissons in New Jersey. The structure is of cast iron with concrete lining and was completed on May 12, 1924.

TEMPORARY BLANKET

It was necessary to place a temporary blanket in order to carry the headings of Contract No. 3 in safety to the end of the Contract. A permit for placing this blanket was obtained from the United States War Department. In connection with driving the shields of Contract No. 4 under the main channel of the Hudson river, there was a tendency to shoal the channel immediately in front of the advancing shield due to the pushing up of the river bottom. As this channel was used by deep draft vessels, it was necessary to maintain a sufficient depth for the passage of all ships. Methods were worked out through the cooperation of the United States District Engineer's office under the supervision of Col. Slattery, whereby shield driving was not retarded and at the same time provision was made for the safe passage of ships.

CONCRETE

Concrete lining in the South Tunnel West and in the River Tunnels, between Land and River Shafts, has been placed as described under Contract No. 3.

PLATE Nº 8

TABLE OF DECOMPRESSIONS AT VARIOUS PRESSURES AND CASES OF COMPRESSED AIR ILLNESS (BENDS)
UP TO DECEMBER 31, 1924

FILE NO. 16, ACC. NO. 1, PAGE NO. 203
OFFICE NO. 0, CONTRACTS NOS 1,3 AND 4.

	CONTRACT NO. 1 (N.Y.)				CONTRACT NO. 3 (New York)						CONTRACT NO. 4 (New Jersey)																	
	(North) Land Shaft Caisson		(South) Land Shaft Caisson		North Tunnel (Spring St.)		South Tunnel (Canal Street)		River Shaft Caisson		North Land Shaft Caisson		South Land Shaft Caisson		North River Shaft Caisson		South River Shaft Caisson		North Tunnel East		South Tunnel East		North Tunnel West		South Tunnel West		TOTAL	
Pressure lbs. per sq. inch	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends	Decom-press-ions	Cases of Bends
	Note No.1		Note No.1		Note No.1		Note No.1		Note No.2		Note No.1		Note No.1		Note No.2		Note No.2		Note No.1		Note No.1		Note No.1		Note No.1			
1					30		179																				209	--
2											241		113														354	--
3											200		413														613	--
4	264		95		28						182		143														712	--
5	133				11		383		248		229		215												2,456		3,675	--
6	110				154		125				241												4,784		2,729		8,143	--
7	245		410				106				219		111												5,579		6,670	--
8			123		206		184				276		333										2,509		2,593		6,224	--
9	136				256		429				42		119										4,026		4,466		9,474	--
10	231				3,037		695				298		244								2,088		3,008		97		9,698	--
11	135		146		2,772		1,152				153		333						21				3,842		2,874		11,428	--
12	26				4,840		2,872				267		119		37						3,448		5,105		944		17,658	--
13	137		145		2,793		1,797				407		338								2,626				2,199		10,442	--
14					3,839		2,021				279		597						7,504		5,548				3,154		22,942	--
15	141				5,623		5,979				307		341				58		10,697		11,931				1,382		36,459	--
16					7,466		2,471		368		739						60		2,731		2,515				723	1	17,073	1
17	141		142		3,157		3,747		372		768		112		115				5,345		2,168				444		16,511	--
18					5,134		2,742				98		228		344		108		5,118	2	2,502						16,274	2
19	141		277		8,906	1	10,416	1			17		93		38		442		14,339	1	37,108				100		71,877	3
20	143		134		15,601		28,331		413				447		314		106		42,767	6	15,291						103,547	6
21					4,376		3,064		64				246						10,956	10	2,701						21,407	10
22	921				544	2	292		913						359		112		215								3,356	2
23			157		242		586		2,086						288												3,359	--
24					905	4	556		2,315						377		952										5,105	4
25					1,530	2	474		6,537	5	17				609		811										9,978	7
26			56		6,939	3	4,453	5	1,188	3	115		154		178		367		409								13,859	11
27			553	4	8,624	13	6,830	16	487		264	4			636	3			356	1	374	2					18,124	43
28					18,771	16	8,638	13			333	6	132		395	1			4,462	14	1,305	4					34,036	54
29					56,062	71	82,676	147					388	2	945		677	2	14,416	31	15,276	23					170,440	276
30					359		530												1,034	1	385						2,308	1
31					397	1	552								127		602										1,678	1
32					2,084	3									127				3,749	7	3,114	6					9,074	16
33							971	2									152		12,979	21	1,073						15,175	23
34							8,739	9							158				5,352	7	15,122	12					29,371	28
35																											------	--
36															179		755		379								1,313	--
37															186												186	--
38																	749										749	--
39																											------	--
40																											------	--
41															290	1	278										568	1
42															552	2	301										853	2
43															352	2											352	2
44																											------	--
45																											------	--
46															3,178	13	2,257										5,435	13
47															33	1	1,641	2									1,674	3
Total	2,904		2,238	4	164,686	116	181,990	193	14,991	8	5,692	10	5,219	2	9,817	23	10,428	4	142,829	101	124,575	47	23,274		29,740	1	718,383	509

Note No. 1
Pressure, Hours of Work, Etc.
Caisson & Tunnel Construction

Pressure	Work	Rest	Work
0-21	4	1/2	3-1/2
21-30	3	3	3
30-35	2	4	2

Note Nos. 1 & 2
Time of Decompression

Pressure	
1-15 lbs.	- 3 lbs. per min.
15-20 "	2 " " "
20-30 "	3 " " 2 min.
30 lbs. up	1 lb. per min.

Note No. 2
Pressure, Hours of Work, Etc.
Caisson Construction

Pressure	Work	Rest	Work
0-18	4	1/2	3-1/2
18-26	3	3	3
26-33	2	4	2
33-38	1-1/2	5	1-1/2
38-43	1	5	1
43-48	3/4	5	3/4

Plant

The plant installed last year for tunnel driving has been continued in operation during 1924 without material change.

Tunneling and Caisson Sinking Progress

The following tables present informative matter concerning the operations and progress of construction during 1924, information for 1923 can be found in last year's report:

Contract No. 3

North Tunnel—New York

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Air pressure removed,*	......	12/21/23	...	...	....	....	
Compressed air applied to tunnel and tunneling resumed,	71/55.8	2/4/24	49	...	....	....	
Removal of east shield bulkhead of river caisson commenced,	......	2/8/24	...	...	....	....	
Removal of east shield bulkhead of river caisson completed,	......	2/12/24	4	2	....	....	
Erected last permanent ring east of river shaft,	71/28.4	2/16/24	13	11	27.4	2.5	Hudson River silt, gravel and rock.
Removal of west shield bulkhead of river caisson commenced,	......	2/13/24	...	...	....	....	
Removal of west shield bulkhead of river caisson completed,	......	2/21/24	8	4	....	....	
Erected 11 temporary rings of iron in river shaft,	70/99.0	2/24/24	8	5	29.4	5.9	Shield on cradle in shaft.
Erected first permanent ring west of river shaft,	70/99.0	2/25/24	...	...	....	....	
Tunneling stopped for erection of first tunnel bulkhead west of river shaft,	69/71.0	4/25/24	61	52	128	2.46	Practically all rock.
Started erection of cages in river shaft,	......	5/1/24	...	...	....	....	
Tunneling resumed,	69/71.0	5/2/24	8	7	....	....	
Air pressure removed from river shaft and land tunnel between shafts,	......	5/7/24	...	...	....	....	
Completed erection of cages in river shaft,	......	5/19/24	19	17	....	....	
Tunneling stopped because of broken erector,	......	9/17/24	...	...	....	....	
Tunneling resumed,	......	9/19/24	2	2	....	....	
Holed through between New York and New Jersey headings,	......	10/29/24	...	...	....	....	
N. Y. and N. J. shields met,	64/56.3	11/18/24	200	163	514.7	3.16	Hudson River silt, gravel and rock.
Started cross-passage and sump,	......	11/21/24	...	...	....	....	
Started removing compressed air,	......	12/15/24	...	...	....	....	
Compressed air removed,	......	12/17/24	...	...	....	....	
Compressed air temporarily placed on headings,	......	12/26/24	...	...	....	....	

South Tunnel—New York

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Compressed air applied to tunnel and tunneling resumed,**	70/10.2	1/22/24	63	...	....	....	
Removal of east shield bulkhead of river caisson commenced,	......	1/28/24	...	...	....	....	
Removal of east shield bulkhead of river caisson completed,	......	1/29/24	2	2	....	....	Hudson River silt, gravel and rock.

*Air pressure was removed while the New York River Shaft was being sealed and made ready to receive the shields.

**This tunnel was under free air while the New York River Shaft was being sealed and made ready to receive the shields.

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Erected last permanent ring east of river shaft,	69/87.5	2/4/24	14	12	22.7	1.9	
Removal of west shield bulkhead of river caisson commenced,	......	1/31/24	...	...	....	....	
Removal of west shield bulkhead of river caisson completed,	......	2/2/24	3	3	....	....	
Erected 11 temporary rings of iron in river shaft,	69/59.2	2/11/24	8	6	28.3	4.72	Shield on cradle in shaft.
Erected first permanent ring west of river shaft,	69/59.2	2/13/24	...	...	....	....	
Tunneling stopped because of blow and flooding of tunnel,	68/45.9	4/2/24	49	42	113.2	2.70	Hudson River silt, gravel and rock.
Tunneling resumed,	68/45.9	4/10/24	8	7	....	....	
Tunneling stopped for erection of first tunnel bulkhead west of river shaft,	68/26.0	4/19/24	10	9	19.9	2.21	Hudson River silt, gravel and rock.
Tunneling resumed,	68/26.0	4/26/24	7	6	....	....	
Started erection of cages in river shaft,	......	5/1/24	...	...	....	....	
Air pressure removed from river shaft and land tunnel between shafts,	......	5/2/24	...	...	....	....	
Completed erection of cages in river shaft,	......	5/19/24	...	...	....	....	
Tunneling stopped because of distorted shield,	67/16.1	6/12/24	48	37	109.9	2.97	Practically all rock.
Tunneling resumed,	67/16.1	6/24/24	13	6	....	....	
Tunneling stopped to drive bottom drift to meet New Jersey heading,	62/85.3	12/2/24	161	130	430.8	3.31	Hudson River silt, gravel and rock.
Holed through between New York and New Jersey headings,	62/40.0	12/7/24	...	...	....	....	

CONTRACT No. 4

NORTH TUNNEL EAST, NEW JERSEY

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Shield through east shield bulkhead of river caisson,	37/67.9	12/31/23	12	10	38.0	3.80	Passing through caisson.
Heading shut down to place concrete seal at caisson drums and erect lock bulkhead,	......	1/16/24	...	...	....	....	
Tunneling resumed,	......	1/23/24	...	...	....	....	
Progress slowed down as rock is approached,	61/55.3	6/28/24	180	151	2387.4	16.8	River silt.
Cutting edge encountered rock,	62/78.9	7/31/24	33	26	123.6	4.6	River silt and gravel.
Holed through between New York and New Jersey headings,	64/56.3	10/29/24	...	...	....	....	
Cutting edge reaches end of contract and shield stopped,	64/50.0	11/3/24	95	79	171.1	2.2	River silt, gravel and mica schist.

NORTH TUNNEL WEST, NEW JERSEY

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Shield erection commenced,	......	7/21/24	...	...	....	....	
Shield erection completed,	......	9/2/24	43	36	....	....	
Compressed air applied to shield chamber,	......	9/2/24	...	...	....	....	
Removal of west shield bulkhead of land caisson commenced,	......	9/2/24	...	...	....	....	
Removal of west shield bulkhead of land caisson completed,	......	9/9/24	...	...	....	....	
Shield advanced, excavation begun,	24/24.9	9/10/24	8	7	....	....	
Position of cutting edge of shield,	18/14.8	12/31/24	112	90	610.1	6.8	River silt, sand, clay and gravel.

SOUTH TUNNEL EAST, NEW JERSEY

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Tunneling resumed after placing tunnel bulkhead,*	24/70.9	11/29/23	17	14	....	....	
Progress slowed down as river caisson is approached,	35/04.17	3/3/24	95	76	1033.3	13.6	Hudson River silt.

*Tunneling had been stopped to permit erection of tunnel bulkhead and installation of shaft cages.

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Removal of west shield bulkhead of river caisson commenced,	......	3/31/24	28	24	....	....	River silt.
Cutting edge of shield entered caisson,	35/91.90	4/2/24	2	2	87.7	3.4	River silt.
Removal of east shield bulkhead of river caisson commenced,	......	4/8/24	6	5	....	....	
Cutting edge of shield through east shield bulkhead of caisson,	36/28.80	4/19/24	11	10	36.9	2.5	
Heading shut down to place concrete seal at caisson drums and erect lock bulkhead,	......	5/5/24	...	...	....	....	
Tunneling resumed,	......	5/12/24	...	...	....	....	
Progress slowed down as rock approached,	60/25.67	9/30/24	164	136	2396.9	17.6	River silt.
Cutting edge encounters rock,	61/29.60	10/27/24	27	22	103.9	4.7	Gravel and river silt.
Holed through between New York and New Jersey headings,	62/40.0	12/7/24	...	...	....	....	River silt, gravel and
Position of cutting edge of shield,	62/80.7	12/31/24	65	52	151.1	2.9	mica schist.

SOUTH TUNNEL WEST, NEW JERSEY

Operations	*Station*	*Date*	*Time Days*	*Act. Work. Days*	*Prog. Feet*	*Feet Work. Day*	*Material*
Shield erection commenced,	......	4/13/23	...	...	....	....	
Shield erection completed,	......	5/12/23	29	25	....	....	
Compressed air applied to working chamber,	......	5/14/23	2	1	....	....	
Removal of west shield bulkhead of land caisson commenced,	......	5/14/23	...	...	....	....	
Removal of west shield bulkhead of land caisson completed,	......	5/23/23	...	...	....	....	
Shield advanced and excavation begun,	22/86.5	5/24/23	10	9	....	....	
Tunneling stopped for erection of tunnel bulkhead,*	21/27.3	6/27/23	34	29	159.2	5.5	River silt and cinders.
Cages in operation, air pressure applied between bulkhead and shield; tunneling resumed,	21/27.3	12/17/23	173	148	....	....	
Shield at revised end of contract,	14/12.1	4/2/24	108	89	715.2	8.0	River silt, sand, clay and gravel.
Bulkhead constructed at end of contract and air pressure removed,	......	4/14/24	12	10	....	....	
Shield dismantled and iron lining erected to end of contract,	......	6/17/24	64	54	....	....	

NEW YORK RIVER CAISSON

(*Note: See Plate No. 6, Annual Report for* 1923 *for details of Sinking, etc.*)

Compressed Air Placed on Caisson,**	(5 lbs.)	January 2, 1924.
Waterproofing Started,	5 lbs. Comp. Air	January 2, 1924.
Waterproofing Completed,	5 lbs. Comp. Air	January 4, 1924.
Compressed Air Removed,		January 4, 1924.
Concrete Invert Started,		January 4, 1924.
Concrete Invert (bottom seal) Completed,		January 9, 1924.

NEW JERSEY SOUTH RIVER CAISSON

Steel erection completed, sinking resumed, elevation 232.0,	......	12/20/23	21	18	0.4	....	Hudson River silt.
Caisson landed in final position, elevation 193.67,	......	1/23/24	34	25	38.3	1.5	Hudson River silt.
Bottom seal completed,	......	2/3/24	11	9	....	....	

*No further work was done in this tunnel until after the erection and starting of the east tunnel shield and the installation of cages.

**Compressed air had been temporarily removed after caisson landed in final position.

COMPRESSED AIR ILLNESS

During the year the major part of the work has been in air pressures between 29 and 34 lbs. There have been no fatalities from compressed air illness and in but one instance has there been any permanent injury. In this case an employee of the Contractor violated the law regulating decompression. The total number of cases of compressed air illness during 1924 was 334, out of a total of 408,430 decompressions during the year; of these 18 cases were in the Engineering Staff.

Since the beginning of the work there have been 509 cases of compressed air illness out of a total of 718,383 decompressions; of these 32 cases were in the Engineering Staff. These records demonstrate that with careful supervision as to selection of men, re-examination and the enforcement of the decompression requirements, the hazards inherent to compressed air work can be materially reduced.

The table on Plate No. 8 gives the number of decompressions in all compressed air work to date, with the number of cases of bends at each working pressure.

CONTRACT NO. 5

Contractor	Rodgers & Hagerty, Inc.
Date of Contract	July 17, 1923
Contract Time	Two Years
Contract Bid Price	$3,467,413.50
Estimated Value of Contract to Date	$2,713,197.01
Total Amount Certified to Date for Payment	$2,441,877.32
Total Amount of Retained Percentage	$271,319.69

This contract provides for the construction of the approach tunnels from the New York Land Shafts in Spring and Canal Sts. to the open approaches at Dominick and Hudson Sts. It includes about 1967 ft. of open cut work and the foundations for the New York Ventilation Building on the west side of Washington St. between Spring and Canal Sts. The annual report for 1923 stated that excavation in the North Tunnel had been about 60% completed. During this year, the remaining excavation in the North Tunnel, and all excavation in the South Tunnel and for the foundations of the Ventilation Building, has been completed.

Steel sheet piling was used in both the Spring St. and Canal St. Tunnels from the Land Shafts near Washington St. to the west side of Hudson St. This sheeting was driven below subgrade before excavation progressed below ground water level, the upper 12 ft. of excavation which was above ground water level being held with wooden sheeting. All steel sheeting is to be left in place. Extending east from the west side of Hudson St., both sides of the excavation were supported for their entire depth with timber sheeting. In general, the bracing was of 12" x 12" timbers, spaced 10 ft. apart horizontally, and varying from 3 ft. to 5 ft. apart vertically, the spacing depending upon the load to be supported. To insure a minimum disturbance of buildings and adjacent structures, timber struts were immediately placed under stress equal to lateral earth pressures by the use of screw jacks and steel plates and wedges. This method has been very satisfactory as there was practically no earth movement.

One of the most difficult features in connection with the work was the excavation of sand in ground water. This was successfully done by sinking sumps at frequent intervals and lowering the general ground water level by pumping so that excavation was practically in dry

material. A great deal of care had to be exercised in excavating material near subgrade in both Canal and Spring Sts., west of Greenwich St. where the water level could not readily be lowered or where springs were found. Such excavation was accomplished by spreading gravel over the surface of the sand and carefully trenching in order to drain the ground water to the sumps.

After the cut had been excavated to grade, a series of vitrified pipe drains from 8" to 12" in diameter were laid throughout the entire length of each excavation and connected with sumps. Complete drainage of the ground was obtained in this way so that the concrete base upon which the waterproofing was placed was poured without interference from water.

In carrying the North Tunnel structure under a six-story brick building at No. 286 Spring St. and 290 Hudson St., temporary underpinning was used and the building finally supported by the roof of the tunnel structure. This work was completed with no structural damage to the building. Underpinning of the elevated railroad columns on Greenwich St. has been completed, except for the concreting of grillage under three columns which are to be supported by the roof of the completed tunnel.

Particularly deserving of comment is the method used by the Contractor for the support of the Canal St. trunk sewer. This is a very old structure, consisting of a brick arch resting upon rough ashler walls, which according to report were a part of the old canal constructed over one hundred years ago. The thickness of the arch at the crown is 12". The span varies from 14 to 16 ft. with a rise of about 4 ft. The New York Central Railroad Co. operated two tracks over this sewer from Hudson St. to Washington St., but due to the condition of the sewer the Transit Commission ordered the Railroad Company to cease operating over these tracks until the arch was strengthened.

The question of supporting and maintaining the sewer was given most careful consideration as the north neat line of the tunnel excavation ran parallel to and only a few feet from the sewer and extended below the sewer from 17 to 37 ft .

The method adopted by the Contractor was the most effective, as the results showed. The sketch on Plate No. 10 illustrates a section of the sewer with the adjoining bracing in the tunnel excavation acting against the concrete filler between the sheeting and the sewer. This filler in conjunction with the steel sheeting completely sealed off all seepage from the sewer even at flood tide. The movement of the sewer due to settlement was prevented by using steel plates and wedges for tightening the supporting timber and also by grouting behind the sheeting on the south side of the tunnel structure to solidify all disturbed ground.

The street surface at the junction of Canal, Hudson and Desbrosses Sts. has been raised, together with the tracks of the New York Central Railroad Company and the New York Railroad Company. A permanent pavement has been placed on the major area affected by the new grades. East of Renwick St. backfilling of the North Tunnel has been completed, except where subsurface changes are still in progress.

The Contractor's buildings and a central concrete mixing plant are located on plant sites furnished by the Commissions on the southeast corner of Broome and Hudson Sts. Concrete from this plant is dumped directly into trucks or buckets carried on trucks. It requires but a few minutes' time to haul it to the various parts of the work.

Gratifying progress has been made on this Contract throughout the year. The North Tunnel structure has been practically completed with the exception of placing copper steel plates in front of the air ports on each side of the roadway, finishing the concrete surface and final cleaning. In the South Tunnel all the steel is in place, excepting a few beams near the Canal St. Caisson, 65% of the concrete has been placed and 70% of the waterproofing has been done. Excavation for the foundation of the ventilation building has been completed.

CONTRACT No. 5-A

Contractor, ... Rodgers & Hagerty, Inc.
Date of Contract, ... November 25th, 1924
Date of Delivery of Contract, ... December 13th, 1924
Contract Time, ... Ten months
Contract Bid Price, ... $301,312.25

This contract provides for open approaches between Dominick Street and Broome Street and on Canal Street between Hudson Street and Varick Street, New York City.

Work was started on December 24th, 1924, when L. J. Cohen, Inc., subcontractor, commenced the demolition of buildings at 578, 580 and 582 Broome Street, and on December 26th, 1924, Rodgers & Hagerty, Inc., began the laying of an air line on Dominick and Varick Streets, extending to Broome Street.

CONTRACT No. 6

Contractor, ... Booth & Flinn, Limited
Date of Contract, ... November 25th, 1924
Date of Delivery of Contract, ... December 23rd, 1924
Contract Time, ... Ten months
Contractor's Bid Price, ... $2,582,969.75

This contract provides for open approaches and tunnels between Provost Street and a point about one thousand (1,000) feet west of the river bulkhead near the line of Twelfth Street produced, Jersey City, New Jersey, where connection is made to the river tunnels. The tunnels extend under the Erie R. R. and D. L. & W. R. R. yards and come to grade at the east side of Provost Street, the North Tunnel in Fourteenth Street and the South Tunnel in Twelfth Street.

The relocation of railroad tracks in the Erie R. R. and D. L. & W. R. R. freight yards, preparatory to turning the contract site over to the contractor, was started on November 24th in the case of the Erie R. R., and on December 9th in the case of the D. L. & W. R. R. The contractor began work preparatory to sinking the foundations of the ventilation building on December 22nd, 1924.

DESIGNS, STUDIES AND INVESTIGATIONS

The work carried on in the Designing Department consisted of studies, investigations and designs in connection with making contract drawings and construction drawings; plans for the development of plazas and preparation of condemnation maps; also special studies of mechanical, electrical and architectural features which apply to ventilation and other equipment, and to the interior finish of the tunnel.

A special investigation has been carried on with respect to tile for the lining of the tunnel walls and a report made for the purpose of preparing specifications for this important element of the finish of the tunnel. During the latter part of the year the preparation of specifications for the equipment contracts has been in progress.

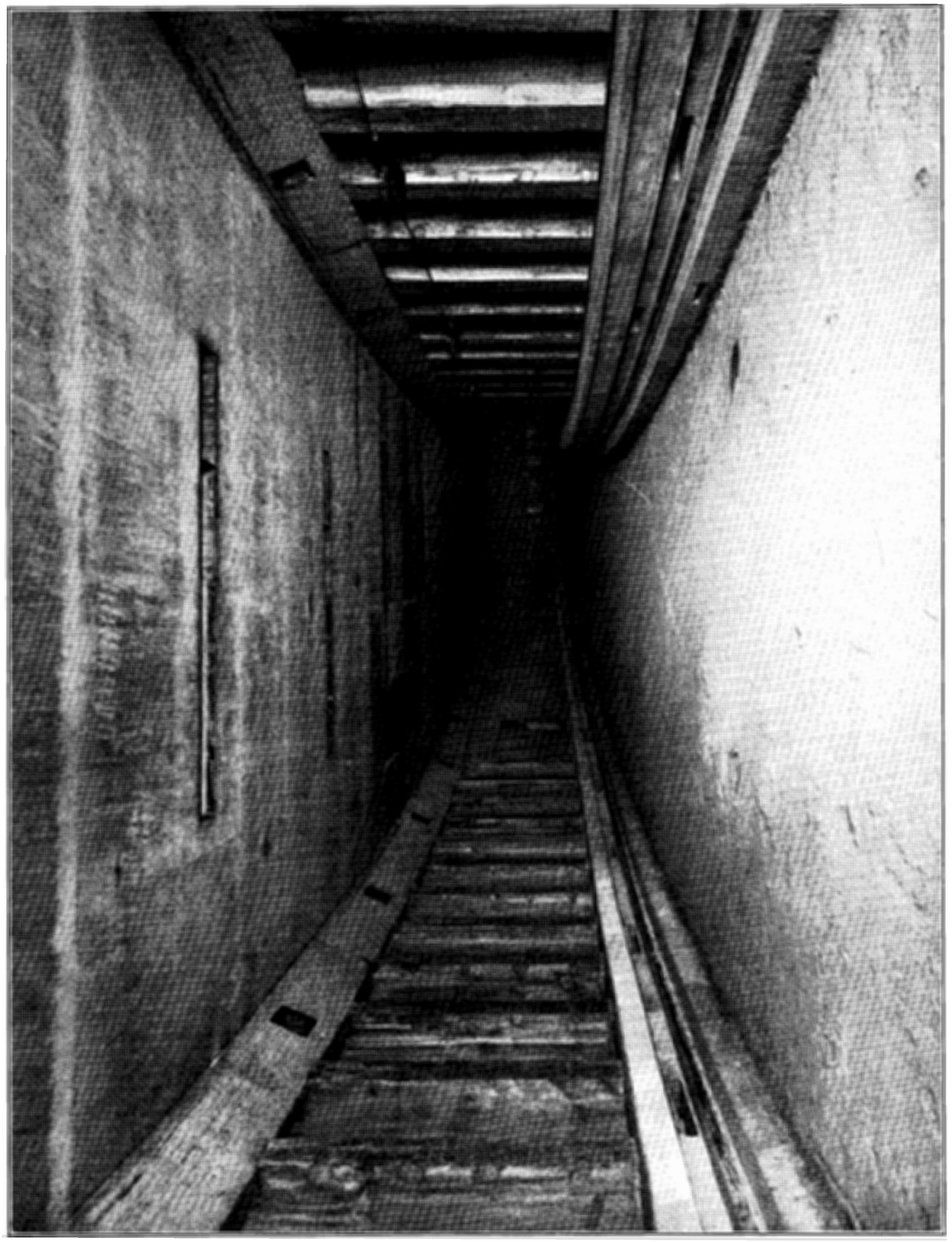
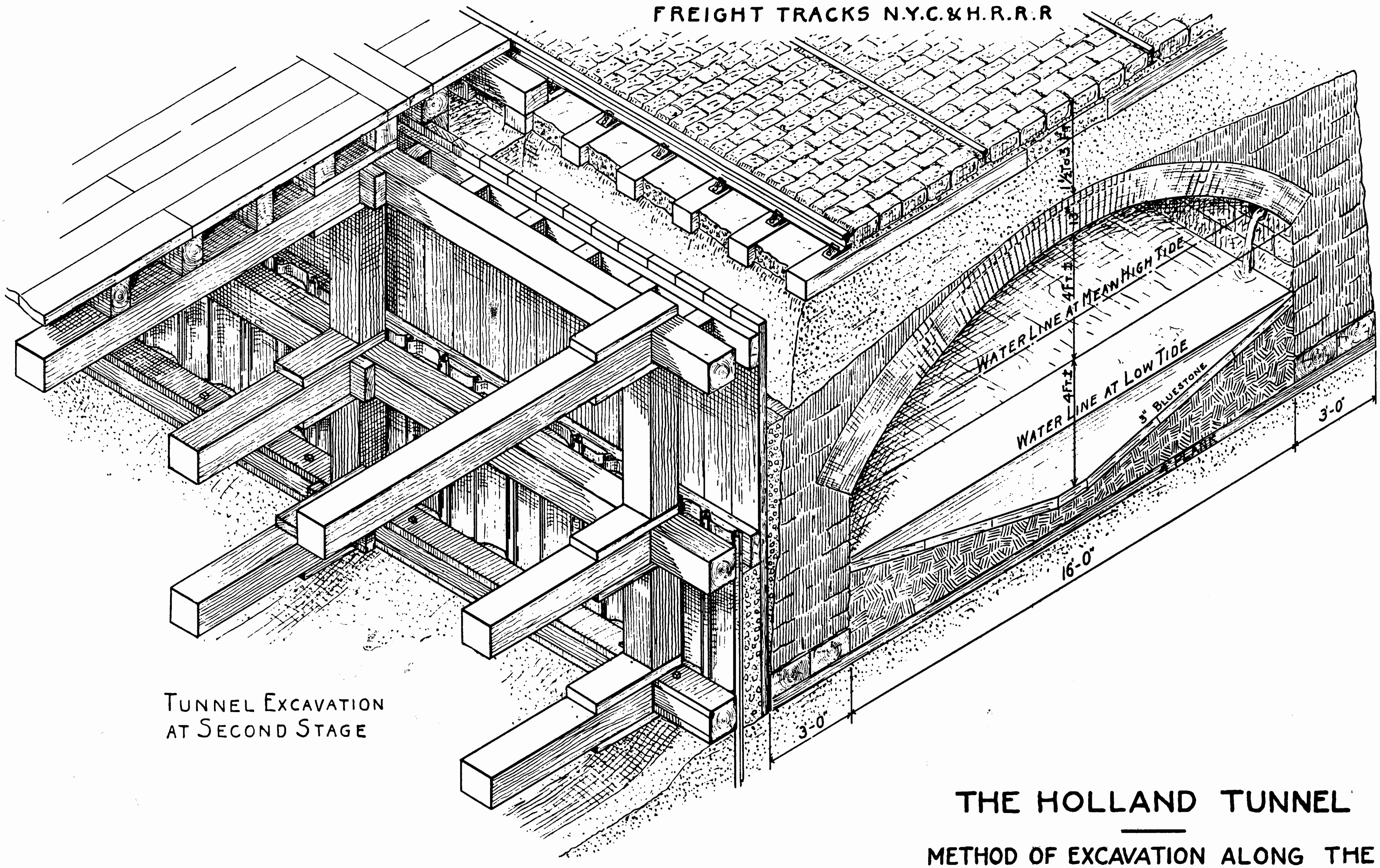


PLATE No. 9—Partially Completed Tunnel Section, North Tunnel. Contract No. 5.

PLATE No 10



THE HOLLAND TUNNEL

METHOD OF EXCAVATION ALONG THE CANAL STREET SEWER

PLAN PREPARED BY RODGERS & HAGERTY INC.
CONTRACTOR FOR CONTRACT No 5

Early in the year studies and investigations were completed preparatory to making contract drawings for Contracts Nos. 5-A and 6. In the case of the latter contract, the presence of an old timber crib filled with heavy riprap under portions of the site of the New Jersey Land Ventilation Building, as well as under the air ducts connecting with the tunnel, greatly complicated the design of the foundations for this structure and in order to keep the cost of these foundations within reasonable limits, negotiations were opened with the Erie Railroad Company with a view to modifying the Erie Agreement. The original agreement provided that the tunnel structure should support a warehouse to be constructed over the tunnel by the Railroad Company. A modifying agreement was made to the effect that the warehouse is to be located further to the west and the loads to be applied to the air duct structure substantially lightened. This agreement effected a considerable saving in the cost of foundations and eliminated much of the expensive pile or caisson construction through the riprap filled timber crib. The contract drawings for this work were completed during September.

Work has been continued throughout the year on Contracts Nos. 3, 4 and 5 furnishing construction plans and giving additional details to the contractor as required. Included in this work is furnishing final locations of concrete lining for the tube sections. Due to irregularities of shield driving, which are inherent in all tunnels built by this method, it is necessary to adjust the line and grade of the roadway to the position of the cast-iron lining as built to give a uniform line and grade to this roadway. The steel forms used by the contractor for concreting were checked to determine their adaptability to the varying sections of the tunnel.

Complete structural and concreting plans were furnished the contractor of Contract No. 5, supplementing the contract drawings, and complete shop drawings covering all of the structural steel work as furnished by the fabricating company have been checked, corrected and approved. In addition drawings were issued showing subsurface structures which had to be changed to avoid interference with the tunnel.

Negotiations have been carried on with the City of New York for making the necessary street changes in the vicinity of the tunnel entrance and exit.

Condemnation maps have been prepared showing all additional property to be acquired in New York City, in accordance with the resolutions adopted by the Commissions for the enlarged plazas. In New Jersey complete condemnation maps have been made showing all lands and easements to be acquired for the tunnel approach and the plazas, conforming to the plan for enlarged plazas referred to above.

Work has been under way on the final calculations for the power required to ventilate the tunnel. Modifications of previous calculations have been necessary to take care of conditions in the air ducts as actually constructed. In this connection, air measurement apparatus has been installed in the completed portion of the tunnel so that a check can be obtained on the distribution of the air in the ducts. In one section of the tunnel a more complete set of air measurement apparatus is being installed for the purpose of obtaining a check on the data developed from the experimental investigations made on models. The question of dust content of the air, particularly in the railroad yards in Jersey City, has been investigated and provision made so that air filtering apparatus may be added if future conditions make it necessary.

Detail electrical drawings have been prepared for the parts of the tunnel under contract. Designs for the complete electrical installation for the tunnel are in course of preparation. An experimental installation of tunnel lighting was made in a completed section of the tunnel and proved satisfactory in respect to the amount and distribution of the light.

During the year architectural studies of the ventilation buildings have been further developed and are now practically in their final form. Architectural plans of the plazas have also been in progress and in this connection scale models of the New York and New Jersey plazas, including detail architectural work around the entrance and exit have been made. These models show correctly in detail the surrounding buildings and have proved of great benefit in working out the architectural features.

Change of temperature and conditions of moisture make the quality of the tile lining one of prime importance. For this reason extended investigations have been made of the quality and kind of tile best suited to use in the tunnel. Prof. G. H. Brown, of Rutgers College, was retained to carry this investigation still further to obtain adequate assurance that an entirely practicable and suitable tile might be found. Data as to the results of the investigations are given in Appendix No. 1.

MISCELLANEOUS INVESTIGATIONS AND STUDIES

During the year, studies previously begun were continued, including sea-water tests on cement, protection coating for steel, daily record of temperature of air and Hudson River water, investigations of earth pressures upon the tunnel linings and river caissons, including the physical properties of the silt and other phases of the subject which aid in explaining tunnel movement phenomena. In addition to this, the triangulation system, upon which the tunnel surveys depend, was checked. Many other tests were made, primarily to determine the quality of the materials of construction.

All phases of earth pressure investigations begun in 1923 have been continued, together with such other studies as have presented themselves in carrying out this work. These include the determination of the weight and water content of silt, the determination of conjugate and other pressures, tensile strength and frictional cohesion. These studies are not yet completed and definite data thereon is not yet available.

A complete recheck of the triangulation survey was made. The results agreed very closely with those of the original triangulation. Elevations across the river were checked by reciprocal levels and by connecting with bench marks of existing tunnels under the Hudson River.

Photographs were made during the year to picture the progress of the work and also to illustrate and make a record of any special method of tunneling or special device employed.

A record of costs was continued until May 17th, 1924, when the field work reached its maximum and required all available men on contract work.

INSPECTION OF MATERIALS

The quantities of the principal materials required for work now under contract as supplied by the subcontractors and the approximate quantity manufactured during 1924, and the quantity manufactured to date are listed herewith.

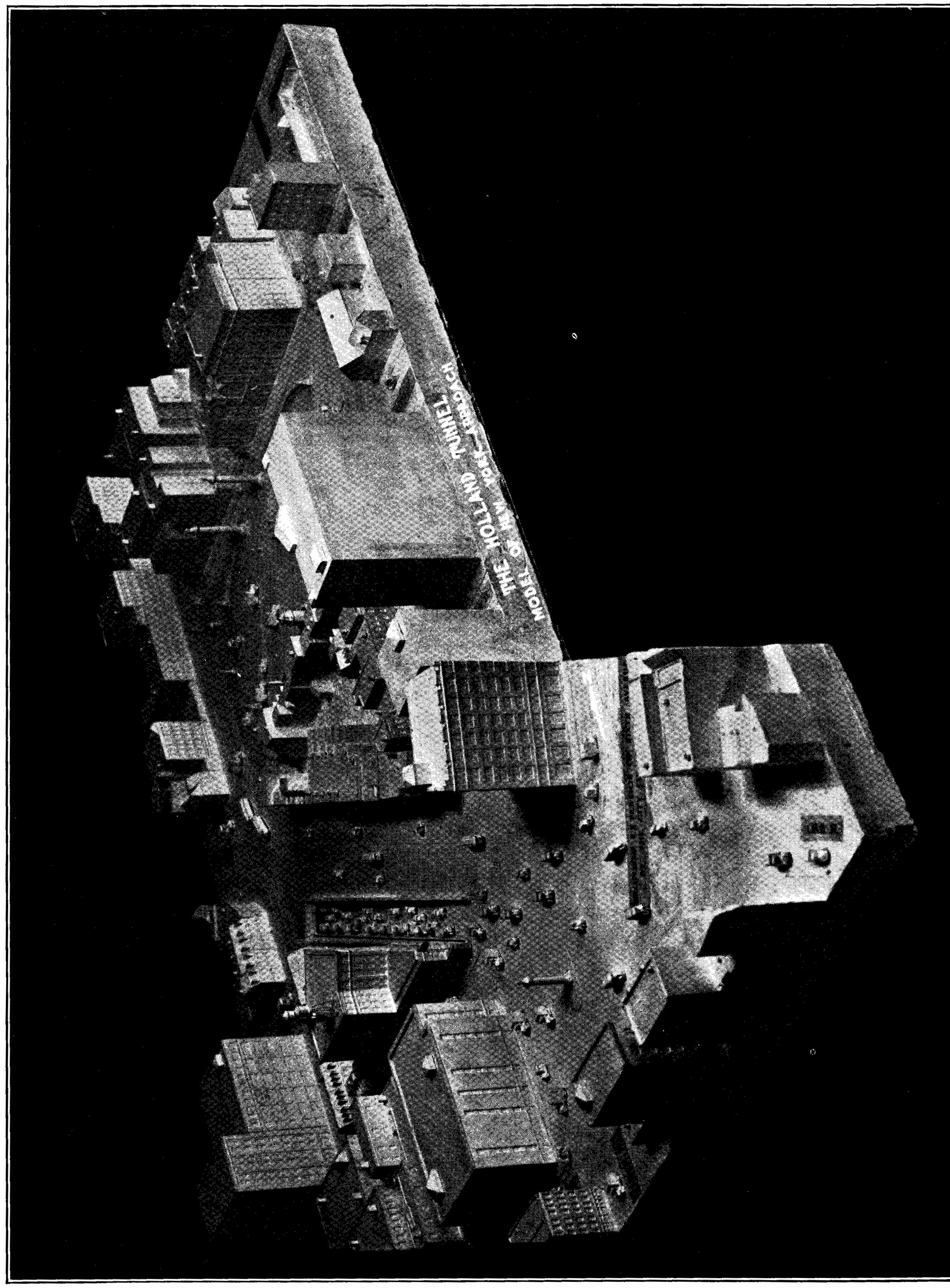


PLATE No. 11—Model New York Plazas.

Material	*Unit*	*Approx. Quantity*	*Subcontractor*	*Mfd. during 1924*	*Total Mfd to Date*	*Per cent completed Dec. 31, 1924*
Cast-iron tunnel lining, ...	Ton	38,000	Davies & Thomas Co., Catasauqua, Pa., ...	232	37,852	100
Cast-iron tunnel lining, ...	Ton	68,500	Bethlehem Steel Co., Bethlehem, Pa., ...	6,140	69,140	100
Cast-steel tunnel lining, ...	Ton	7,800	Bethlehem Steel Co., Bethlehem, Pa., ...	1,924	7,784	100
Structural steel for caissons, ...	Ton	4,507	Bethlehem Steel Co., Steelton, Pa., ...	....	4,507	100
Structural steel for cut and cover section, Contract No. 5, ...	Ton	4,500	American Bridge Co., Trenton, N. J., ...	3,079	4,279	100
Tunnel bolts, Contracts Nos. 3 and 4,	No.	437,300	Pittsburgh Screw & B., Pittsburgh, Pa., ...	128,435	434,985	99.4
Tunnel bolts, Contracts No. 3 and 4,	No.	437,300	Bethlehem Steel Co., Reading, Pa., ...	30,843	436,794	99.8
Granite facing, ...	Cu.Yd.	401	H. E. Fletcher Co., W. Chelmsford, Mass., ..	....	401	100
Granite curbing, Contracts 3 and 4,	Lin.ft.	27,210	H. E. Fletcher Co., W. Chelmsford, Mass., ...	11,558	25,158	92
Granite curbing, Contract No. 5, ...	Lin.ft.	4,104	J. Leopold & Co., W. Sullivan, Me., ...	2,657	2,657	65

The manufacture of steel and cast iron necessary for the river tunnel contracts is practically completed.

The inspection of the ordinary items of iron and steel, such as tie-rods, tunnel bolts, sheet metal air flues, copper steel plates, floor beams, ceiling angles, caisson connecting rings, cast-steel shackles and structural steel for the cut and cover section, with the exception of rolling of steel, was done directly by the engineering staff of the Commission.

Sand and gravel, washers for tunnel bolts, rolling of steel, lead for caulking, grommets, cast-iron water pipe for tunnel service lines, waterproofing fabric and asphalt, noncorrosive metal, brick and paints have been inspected through the Materials Inspection Department of the Transit Commission and Board of Transportation of the City of New York as in 1923.

The sampling and testing of cement have been continued through the State Engineer's office at Albany, and approximately 104,247 barrels of Portland cement and 14,114 barrels of mixed cement have been tested and received to date.

The continuation of the arrangement for inspection by the forces of the Transit Commission and Board of Transportation of the City of New York and the State Engineer's office has placed the services of these experienced organizations at the disposal of the Commissions and avoided the duplication of facilities already available at a considerable saving to the Commissions.

TRAFFIC

Study of the vehicular traffic over all the ferries crossing the Hudson river has been continued. No count was made this year, the figures given below being based on data obtained from the operating companies. Distribution and classification have been determined from these data where applicable, but where the necessary figures were not available, estimates were made using percentages determined from the Commissions' counts made in previous years.

In making the summaries, the ferries have been grouped as in former reports, namely:

FIVE FERRY GROUP

(Nearest the Vehicular Tunnel)

Ferry	*New Jersey Terminal*	*New York Terminal*
Pennsylvania R. R.	Exchange Place	Desbrosses Street
Pennsylvania R. R.	Exchange Place	Cortlandt Street
Erie R. R.	Pavonia Avenue	Chambers Street
D., L. & W. R. R.	Hoboken	Barclay Street
D., L. & W. R. R.	Hoboken	Christopher Street

SIX FERRY GROUP

(Remaining Ferries South of 42d St.)

Central R. R. of N. J.	Communipaw	Liberty Street
Central R. R. of N. J.	Communipaw	West 23d Street
Erie R. R.	Pavonia Avenue	West 23d Street
D., L. & W. R. R.	Hoboken	West 23d Street
D., L. & W. R. R.	14th Street, Hoboken	West 23d Street
West Shore R. R.	Weehawken	Cortlandt Street

FOUR FERRY GROUP

(Ferries at and North of 42d St.)

P. S. Corp. of N. J.	Edgewater	130th Street
West Shore R. R.	Weehawken	42d Street
West Shore R. R.	West New York*	42d Street
Dyckman St. and Englewood	Englewood	Dyckman Street

* Not operating.

The volume of traffic for 1924 as compared with that of previous years is shown in the following table:

DAILY TRAFFIC

FIVE FERRY GROUP

Year	*Total Yearly Traffic*	*Horse Drawn* *No.*	*Horse Drawn* *Percent of Total*	*Motor Driven* *No.*	*Motor Driven* *Percent of Total*	*Total Daily Traffic*	*Percent Increase*
1914, ...	2.839,055	7,655	86.9	1,159	13.1	8,814	...
1915, ...	2,811,249	7,137	82.7	1,497	17.3	8,634	— 2.0
1916, ...	3,042.756	7,218	78.0	2,038	22.0	9,256	7.1
1917, ...	3,297,019	6,785	68.7	3.093	31.3	9,878	6.7
1918, ...	3,496,620	6,270	59.9	4.193	40.1	10,463	5.9
1919, ...	3,731,032	5.093	50.9	5,484	49.1	11,177	6.8
1920, ...	3,853,793	4,904	43.4	6.509	56.6	11,503	2.9
1921, ...	3,889,994	4,532	39.3	7,098	60.7	11,540	0.3
1922, ...	4,220,717	4,575	37.2	7,727	62.8	12,302	6.6
1923, ...	4,477,802	4,057	31.1	8,973	68.9	13,030	5.9
1924, ...	4,350,635	3,326	26.6	9,179	73.4	12,505	— 3.8

SIX FERRY GROUP

Year	*Total Yearly Traffic*	*Horse Drawn* *No.*	*Horse Drawn* *Percent of Total*	*Motor Driven* *No.*	*Motor Driven* *Percent of Total*	*Total Daily Traffic*	*Percent Increase*
1914, ...	2,089,311	5.346	81.2	1,233	18.8	6,579	...
1915, ...	2,090,519	4,936	75.1	1,636	24.9	6,572	...
1916, ...	2,256,501	4,875	69.1	2,184	30.9	7,059	7.4
1917, ...	2,430,803	4,755	62.5	2,855	37.5	7,610	7.8
1918, ...	2,669,003	4,594	55.1	3,739	44.9	8,333	9.5
1919, ...	2,646,042	3,884	47.2	4,344	52.8	8,228	— 1.3
1920, ...	2,361,727	2,972	42.0	4,099	58.0	7,071	— 14.1
1921, ...	2,498,457	2,629	36.9	4,498	63.1	7,127	0.8
1922, ...	2,903,881	2.842	32.5	5,903	67.5	8,745	22.7
1923, ...	3,164,008	2,630	27.2	6,989	72.8	9.619	10.8
1924, ...	2,960,277	2,086	23.7	6,719	76.3	8,805	— 7.8

FOUR FERRY GROUP

Year	*Total Yearly Traffic*	*Horse Drawn* *No.*	*Horse Drawn* *Percent of Total*	*Motor Driven* *No.*	*Motor Driven* *Percent of Total*	*Total Daily Traffic*	*Percent Increase*
1919, ...	2,036,421	444	8.5	4,780	91.5	5,224	...
1920, ...	2,089,035	....	....	....	....	5,400	3.4
1921, ...	2,584,691	455	6.7	6,329	93.3	6,784	25.6
1922, ...	3,007,538	313	4.0	7,474	96.0	7,787	14.8
1923, ...	3,302,524	269	3.0	8,694	97.0	8,963	15.1
1924, ...	3,928,478	271	2.6	10,284	97.4	10,555	16.4

Note.—The traffic for the month of December, 1924, has been estimated, as complete data for this month is not yet available.

The total volume of traffic for all ferries shows an increase of 2.6 per cent over the traffic for 1923. The decrease in horse-drawn and increase in motor-driven traffic continues as was to be expected. The average weekday traffic for all ferries across the Hudson river from Manhattan is now 31,865 as compared with 31,612 in 1923, an increase of 0.8 per cent.

PROGRAM OF WORK FOR 1925

The program of work for 1925 will include the completion of the construction of the tunnel structure under the existing contracts, except the New Jersey Approaches, which will be completed in June, 1926, and the preparation of contracts, specifications and contract drawings and the award of contracts for finishing and equipping the tunnel.

TOTTENVILLE-PERTH AMBOY HIGHWAY CROSSING

Under date of December 4, 1923, the Commissions by resolution directed the Chief Engineer to make an investigation of a bridge or tunnel for pedestrian and vehicular traffic across the Arthur Kill between a point in Tottenville, Richmond county, N. Y., and a point in Perth Amboy, Middlesex county, N. J. The Legislatures in their directions to the Commissions provided for an investigation of the desirability and practicability of such a crossing, a report as to the site or sites where such crossing ought to be constructed and the probable cost thereof. A study was made of the traffic crossing the Kill on the ferries from Tottenville to Perth Amboy and also over the municipal ferry from St. George to South Ferry, and a forecast of traffic was made for the year 1928. The type of structure, whether a bridge or tunnel, was investigated, as well as a study of sites suitable for this crossing. An estimated cost of a bridge adapted to this crossing was made, together with an estimate of the financial returns based upon a reasonable toll charge. A complete report was submitted to the Commissions under date of January 14, 1924, which was included in a report made by each Commission to its respective Legislature as a basis for subsequent legislation.

ORGANIZATION

Designs have been under the supervision of Mr. Ole Singstad, Engineer of Designs; construction under Mr. Milton H. Freeman, Engineer of Construction, and later under Col. Frederic A. Snyder, Assistant Engineer of Construction; the General Office under Mr. E. Morgan Barradale, Assistant to the Chief Engineer.

Prof. William H. Burr, Col. George L. Watson, Prof. Arthur C. Willard, Dr. Edward Levy, Mr. George L. Lucas, Col. William J. Wilgus, Mr. Frank M. Williams and Mr. Frederick C. Noble have been continued as consultants on the project. Mr. Sullivan W. Jones, State Architect of New York, has continued to act as consultant on the architectural features of the undertaking. Mr. Lewis B. Stillwell has been retained during the year as Consultant on Electrical and Mechanical Equipment and Prof. George H. Brown was engaged as Consulting Ceramic Engineer to carry on tests and make recommendations as to a suitable tile for lining the tunnel. To all of these, an expression of thanks and appreciation is given for their cooperation and valuable advice in the conduct of the work. Appreciation is also expressed of the loyalty of the entire staff of the character of service it has rendered.

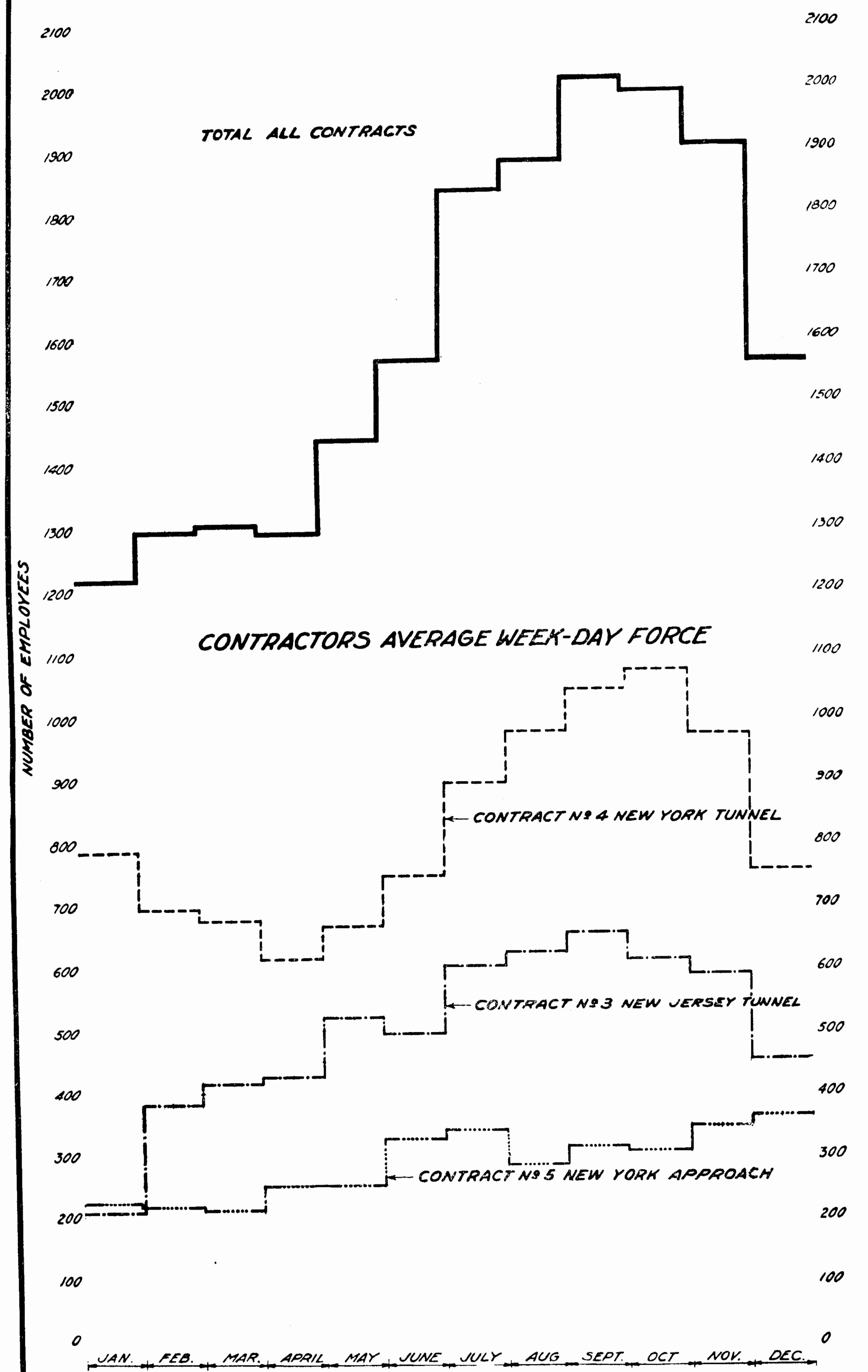
The organization suffered an irreparable loss in the death of its Chief Engineer on October 27, 1924. Mr. Holland had borne the burden of planning and carrying almost to completion a vehicular tunnel under the Hudson river, a pioneer project of great proportions. To the heretofore unsolved problems involved, he brought the highest type of engineering experience and ability with a breadth of view, a spirit of fairness and a zeal for accomplishment rarely found in one man. The accomplishments of the project had already made the Vehicular Tunnel a monument to Mr. Holland's genius, which, after his death, was most fittingly recognized in naming the tunnel The Holland Tunnel.

To the staff, Mr. Holland's death is keenly felt as a personal loss, as well as a loss to the organization. Practically all in responsible positions have been closely associated with him during a long period of years, in an intimate relationship of respect and confidence. His engineering ability, his soundness of judgment, his leadership, his personal charm bound together an organization inspired by his accomplishments. That organization is entrusted with the continuation of the work, and in the spirit engendered under Mr. Holland since this organization was founded is pushing ahead with loyal and conscientious service to bring the project to a successful completion.

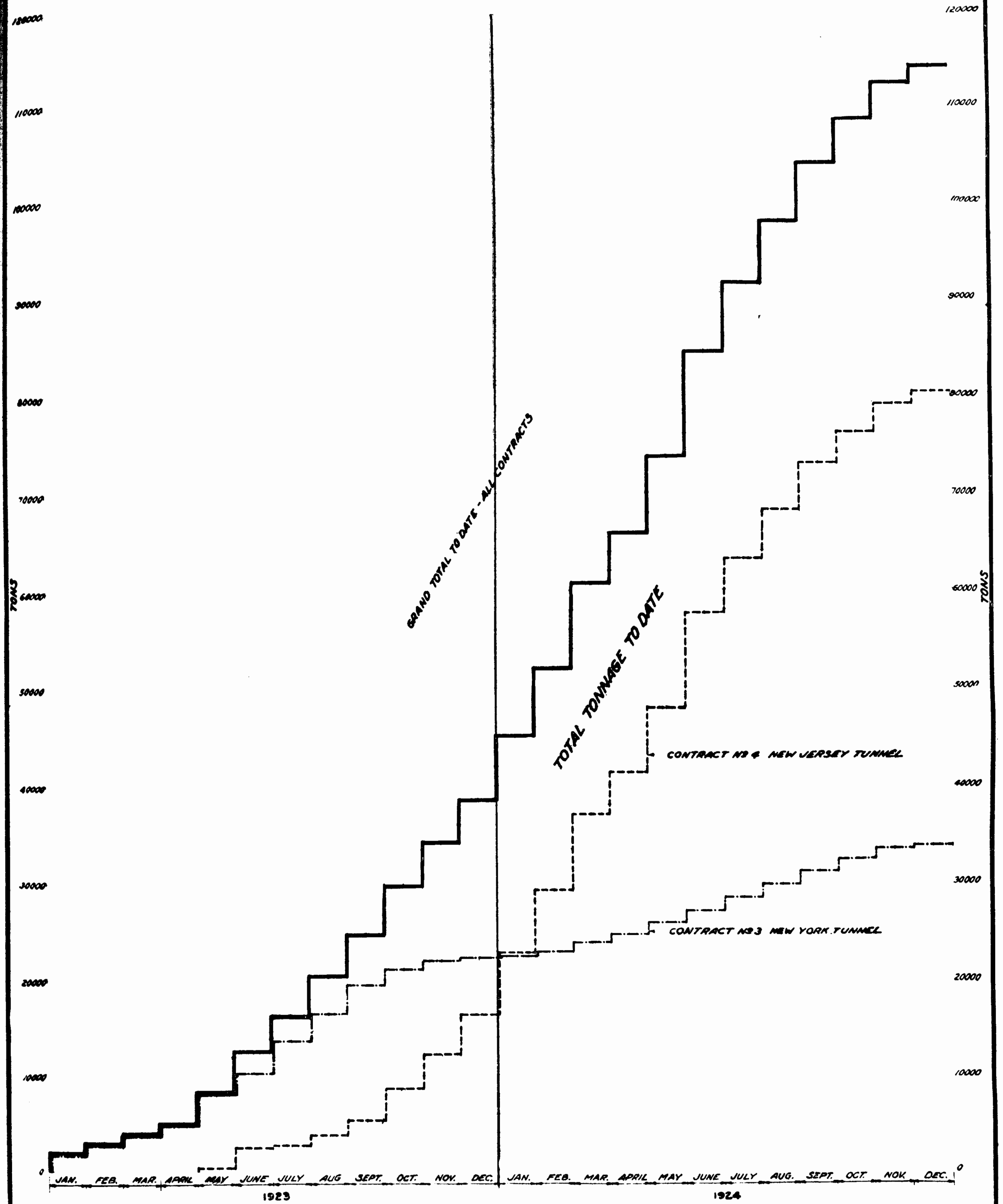
Respectfully submitted,

M. H. FREEMAN,
Chief Engineer.

PLATE Nº 13



CONTRACTORS' AVERAGE WEEK-DAY FORCE
1924



TUNNEL LINING ERECTED IN 1923 AND 1924
INCLUDING CAST IRON, CAST STEEL
AND TUNNEL BOLTS

APPENDIX I

ABSTRACT OF REPORT OF

INVESTIGATION OF GLAZED WALL TILE FOR THE HOLLAND TUNNEL

BY

GEORGE H. BROWN

ADVISORY CERAMIC ENGINEER

APPENDIX I

The Requisite Qualities of Glazed Wall Tile for The Holland Tunnel

In order to improve the appearance, lighting and sanitary conditions of the new tunnels, it is proposed to cover the sidewalls with white or light colored wall tile. In the selection of glazed wall tile for this purpose, the conditions of service to which these tile will be subjected may be considered as follows:

Conditions of Use

Moisture. It is assumed that the interior walls of the tunnels will be at all times in a more or less moist condition—the moisture being introduced mainly through condensation from the air in the tunnels and by seepage of water through the joints of the tunnel walls.

Changes in Temperature. Wall tile used for covering the sides of the tunnels will be subjected to more or less abrupt changes in temperature. As the tunnels will not be heated, it is assumed that the temperatures inside will change with the outside temperatures and will vary from summer heat to below freezing in the winter time. The wall tile will therefore be exposed to alternate freezings and thawings during the winter months.

Mechanical Strength. The mechanical strength of wall tile used in lining the tunnels should be considered. Other qualities being satisfactory, the strength of the tile should be as great as possible, in order to better withstand any strains to which they are subjected due to movements of the tunnel walls and the expansion and contraction of the walls accompanying changes in temperature.

Commercial Wall Tile

In so far as their physical properties are concerned, commercial wall tile may be divided into two classes, *porous* and *vitreous*. Whether a tile is porous or vitreous is determined by measurement of the percentage of water (by weight) which the body of the tile will absorb. A highly porous tile is one which absorbs a relatively high percentage of water. A highly vitreous tile is one which absorbs only a small quantity or no water:

Porous Tile. Most of the wall tile manufactured in the United States and heretofore used extensively in covering the walls of subway stations, etc., are classed as porous tile, i. e., the tile is made up of a porous body covered on one side by an impervious glaze coating. Porous tile of this kind will absorb from ten to twenty-four per cent of their weight in water. If used for the walls of the tunnels, porous tile of this kind would absorb moisture from the air and walls of the tunnels. Obviously, under freezing conditions, the water absorbed by the tile would be frozen and, as the freezing of the water is accompanied by an increase in volume, or expansion, the body of the tile would be subjected to a disruptive action from the ice in its pores. The greater the water absorption of a tile, the greater would be this disruptive action and the greater the liability of cracking, spalling or disintegration of the tile.

Vitreous Tile. A vitreous or vitrified tile is one having a body of low absorption. Vitreous tile will absorb from 0 to 4 per cent. of their weight in water. If used for the walls of the tunnels, the quantity of water absorbed by tile of this type would be very much less than in the case of porous tile, and disruptive action due to alternate freezing and thawing of the water in the pores of the tile would be proportionately less. As a general rule, the lower the percentage of water absorption of a wall tile body or other pottery product, the greater will be the mechanical strength and hence a tile of low absorption would have greater resistance to frost action and other mechanical strains than a tile of high absorption.

SAMPLES SUBMITTED

For the purposes of this investigation, sample wall tile were submitted by twenty-one manufacturers. These tile were representative of commercial light-colored glazed wall tile manufactured in the United States and other countries, in addition to samples made up especially for these tests. The samples were representative of the whole field of glazed wall tile, ranging from tile of very low or zero absorption in some cases up to as high as 24 per cent. absorption in others. In Table I are given complete data as to the samples which were investigated. It will be noted that in this report each make of tile is designated by a letter assigned to it in Table 1.

TESTS SELECTED

In outlining the investigation, the following tests were selected as being best adapted to a determination of the fitness of the various types of tile for lining the tunnels:

1. Absorption test.
2. Quenching test.
3. Natural freezing test.
4. Artificial freezing test.
5. Mechanical strength test.
6. Mortar adhesion test.

The above tests were selected for the following reasons:

Absorption Test.—To determine the per cent. water absorption of the tile. The water absorption of a tile has a direct relation to its resistance to disruption from frost action.

Quenching Test.—To determine the liability of failure of the tile when subjected to changes in temperature.

Natural Freezing Test.—To determine the liability of failure of the tile when subjected to freezing and thawing. This test involves saturating the tile with water and actually freezing in a refrigerator and then thawing—the alternate freezings and thawings being repeated one hundred times.

Artificial freezing Test.—The natural freezing test is a slow and expensive process. The artificial freezing test is much more rapid and less expensive and was employed with a view to its use in determining the resistance of the tile to natural freezing conditions. An attempt was made to correlate the results of the natural and artificial freezing tests with a view to using the latter in the inspection of the tile finally selected and used in the tunnels.

Mechanical Strength Test.—To determine the type of tiles having the highest mechanical strengths and hence best able to withstand strains and stresses in the tunnel walls. The transverse test was selected as being best adapted for this purpose.

Mortar Adhesion Test.—To determine the relation between the water absorption of a tile and its adhesion to the cement mortar used in laying the tile in the walls. This test involved cementing two tile together and measuring the load required to break them apart after the cement had thoroughly hardened.

RESULTS OF THE TESTS

Absorption Test.—The results of the absorption test are given in Table 1. It will be noted that the absorptions range from less than 1% up to 24.6%. Tile having an absorption of less than 4% may be classed as vitreous tile, and those above 4% semi-vitreous or porous tile. Under this classification, nine of the twenty-one samples submitted would be vitreous and twelve semi-vitreous or porous. A visual examination of a wall tile usually suffices to determine whether it should be classed as vitreous or porous.

Quenching Test.—The results of the quenching tests are given in Table 1. Failures due to the quenching tests were usually evidenced by so-called "crazing" (cracking) of the glazed coatings on the tiles. It will be noted that eleven of the twenty-one kinds of tile tested showed no failures in the quenching test. The other ten samples showed crazing in varying degrees ranging from slight crazing of one tile to excessive crazing of all the five tile subjected to this test. It will also be noted that ability to withstand the quenching test does not appear to have direct relation to absorption as both vitreous and porous tile withstood the quenching test successfully. Some of the failures (crazing) due to the quenching test are shown by Plate No. 20.

Natural Freezing Test.—The results of the natural freezing tests are summarized in Table 1. The natural freezing tests were made in the laboratories of the Brunswick-Kroeschell Company, New Brunswick, N. J., manufacturers of refrigerator installations. Three tile of each make were subjected to 100 alternate freezings and thawings. In making the test each tile was saturated with water, frozen at 8° F. for ten hours, then thawed in water at room temperatures, and again frozen. About three months time was required for making the 100 freezings.

From Table 1, it will be noted that nine series of tile of the twenty-one samples tested passed the 100 freezings without showing failures of any kind. The remaining twelve samples were affected in varying degrees. In some cases failure was due to crazing; in others to spalling and disintegration. Plate 21 shows the effect of the natural freezing test on the tile of each make. It will be noted that in general the tile most seriously affected by the natural freezings were those having porous structures and consequently which absorbed considerable amounts of water during the saturations. The tiles having vitreous bodies of low absorptions were in most cases unaffected by the natural freezing test.

Artificial Freezing Test. As previously stated, subjecting tiles to a natural freezing test is a slow and expensive process and would not be feasible in making routine inspection tests of tile as submitted for a job. The time required would be too great. It was therefore decided to subject series of the tile to an artificial freezing test with a view to correlating this test with a natural freezing test. After preliminary tests, it was decided to subject five tile of each make to saturations in a sodium thiosulphate solution, a proceedure which has been followed in the testing of other products in determining their resistance to freezing.

The results of five artificial freezing tests on each make of tile are summarized in Table 1. It will be noted that eight of the twenty-one samples subjected to this test were not affected in any way. The other samples show failures ranging from slight crazing in some cases to spalling and complete disintegration in others. The results of the artificial freezing tests are quite comparable to those of the natural freezing treatment. This will be noted from Plate No. 20, in which are shown a series of tile subjected to this test fifty times.

Mechanical Strength Tests. In Table 1 are given the average results of the transverse tests on samples of the tile. Five tile of each make were tested, the average modulus of rupture for each make being given in the table.

It will be noted that, with a few exceptions, the tile having low water absorption show greater strength than those of high absorption. It is also interesting to note that the very porous tile, i. e., those having absorptions above 14%, show moduli of rupture less than 2000 pounds in every case.

Mortar Adhesion Tests. The results of the mortar adhesion tests are shown in Table 1. These tests were made with a view to comparing the relative adhesive or sticking qualities of vitreous vs. porous tile when laid in Portland cement mortar. In making the tests, two tile of the same make were cemented together with a 50-50 sand—Portland cement mortar (joint 1/8" thick). After setting for 28 days, the tile were placed vertically in a compression machine and sheared apart. It is noted from Table 1 that there does not appear to be a direct relation between adhesive qualities and the absorption of the tile. Thus, tile N, having an absorption of 11.10% developed adhesive strength of 218 pounds per square inch, as against tile I, having an absorption of 0.3% and developing strength of 216 pounds per square inch. However, tile F, having the highest absorption, 24.6%, shows the lowest strength of the series, 75 pounds per square inch.

It would appear that the adhesive qualities of a tile are largely affected by smoothness and the nature of its backing, i. e., whether it has ribs or depressions which assist in holding the tile to the mortar.

CONCLUSIONS

The purpose of this investigation was to arrive at some means of determining the best type of glazed wall tile to be used in covering the side walls of the new tunnels, with a view to proposing specifications under which these tile should be purchased.

Considering glazed wall tile as of two classes, vitreous and porous, the results of the above tests lead to the conclusion that vitreous tile would give better service. This conclusion is borne out by the fact that in many cases where porous wall tile have been used for exterior work—notably in covering the walls of subway entrances and stations, the tile show marked evidences of deterioration due to the conditions of service which are discussed in the above report. The failures noted are most often due to so-called cracking or "crazing" of the glazed surfaces of the tile. Less frequently failure due to chipping off or spalling of the surfaces of the tile are noted and there are instances where the tile show evidences of disintegration or crumbling away.

It has been demonstrated by the above tests that failure due to spalling or disintegration may be caused by the action of frost on porous glazed wall tile, and that glazed wall tile having vitreous bodies successfully withstand this action in every case.

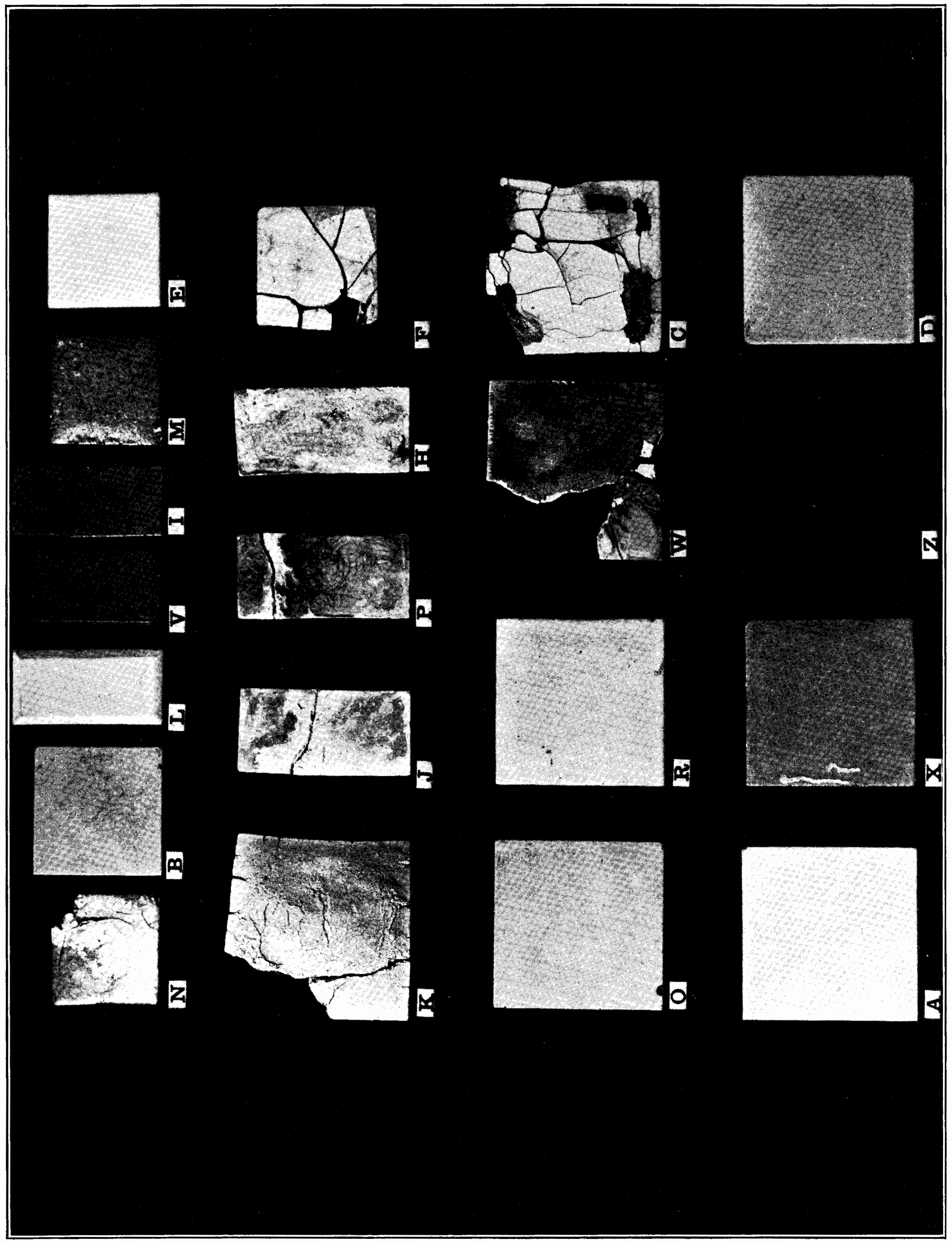


PLATE No. 20—Complete Series of Tile, Artificial Freezing Tests.

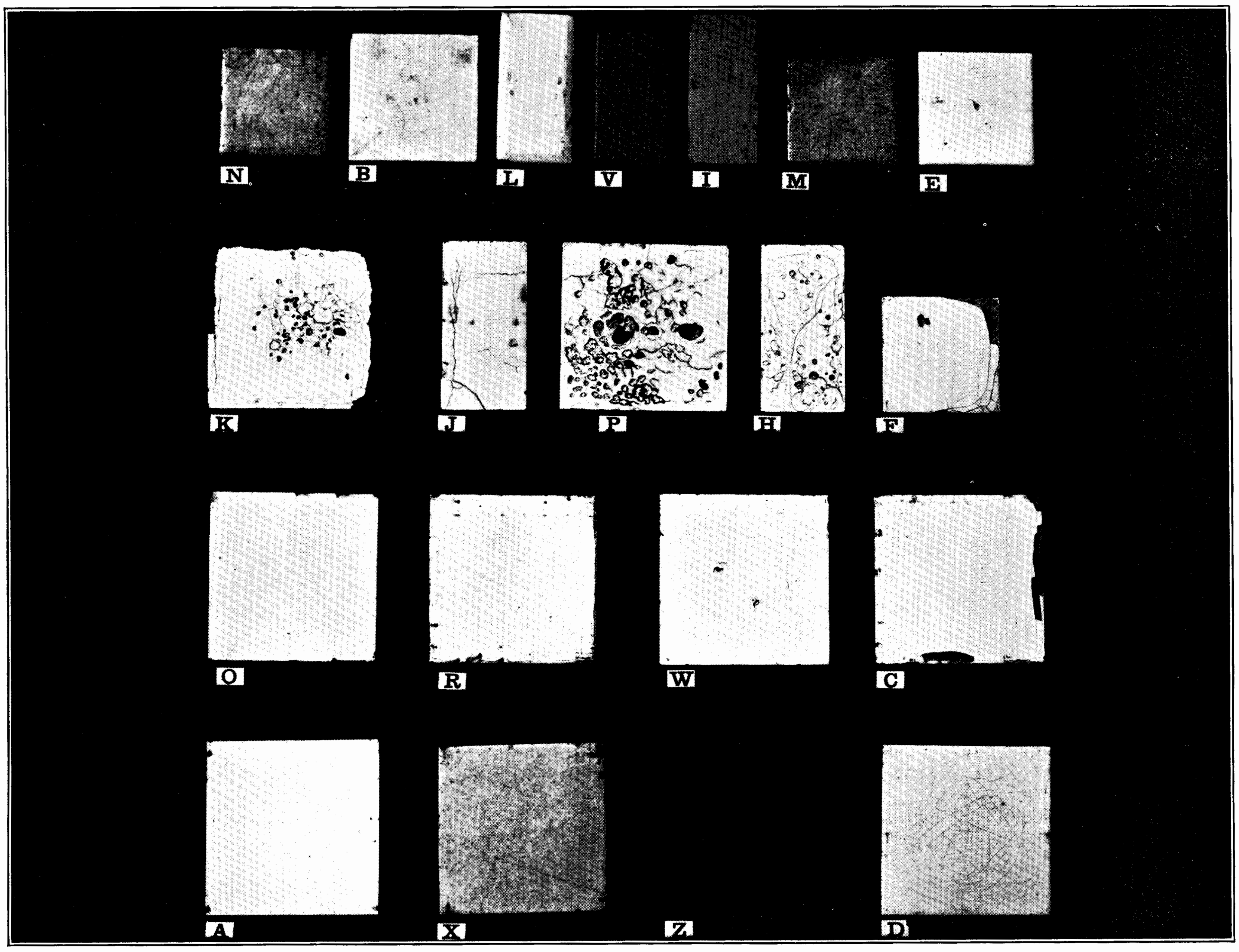


PLATE No. 21—Complete Series of Tile, Natural Freezing Tests.

The deterioration of glazed wall tile from so-called "crazing" or cracking of the glazed surfaces may be caused by subjecting certain tile to sudden changes in temperature or to the action of frost. The crazing of glazed tile is considered objectionable for the reason that the cracks in the surfaces absorb dirt which cannot be removed and hence tile which are crazed are unsanitary and unsightly in appearance. From this investigation we conclude that certain glazes are more resistant to crazing than others. It is a well-known fact that resistance to crazing is governed to a large extent by "glaze-fit", i. e., whether the coefficients of expansion and contraction of the glaze conform to those of the body upon which it is applied. "Glaze-fit" is subject to control through variation in the chemical composition of the glaze itself.

It would also appear from the results of the investigation that glazed wall tile of low absorption (vitreous) possess in general greater mechanical strength than glazed wall tile of high absorption (porous). Although the mechanical strength of the tile used in lining the tunnels may be of secondary importance, other qualities being satisfactory, high mechanical strength would be desirable.

The degree of water absorption of a glazed wall tile does not appear to bear a direct relation to its ability to adhere to a Portland cement mortar. In this investigation highly vitrified tile of low absorption showed excellent bonding properties when laid in Portland cement mortar.

In view of the results of this investigation, specifications covering the purchase of glazed wall tiles for the tunnels should cover the following qualities:

1. Size and uniformity.
2. Color.
3. Absorption.
4. Resistance to freezing and thawing.
5. Resistance to change in temperature.

It does not appear feasible to write specifications covering the mechanical strength and adhesive qualities of the tile to be used. The mechanical strength would be covered to a certain extent by the specifications for absorption. Specifications as to adhesive qualities would involve too much time in making the tests.

DESCRIPTION OF THE TESTS

By F. B. RHODES

Absorption Test.—Five tile of each make were dried for two hours at 110° C; cooled down to room temperature in air and then weighed. This weight was recorded as the dry weight. The tile were then immersed in water and boiled vigorously for one hour; then allowed to remain in this water for twenty-four hours, after which they were removed, dried with a clean towel and weighed again, this weight being recorded as the wet weight. The percentage of absorption was then calculated by the use of the following formula:

$$\text{Per cent absorption} = \frac{Ww - Wd}{Wd} \times 100$$

Ww = wet weight
Wd = dry weight

Quenching Test. 100° C (dry) to ice water.—Five tile of each make were placed in an electric oven—the oven and the tile being at room temperature. The oven was regulated in such a way that the temperature interval between room temperature and 100° C was reached in not less than one hour, and then this temperature of 100° C is held for one hour. The tile are then transferred as quickly as possible to ice water. This procedure is to be repeated five times on each tile.

Artificial Freezing Test. $Na_2S_2O_3$. $5H_2O$—The "solution" used consists of crystalline sodium thiosulphate "melted" in its own water of crystallization. The solution is prepared by heating the crystalline material over a water bath. The inversion of $Na_2S_2O_3 . 5H_2O$ to $Na_2S_2O_3 . 2H_2O + 3\ H_2O$ takes place at 47.9°C and after this temperature is reached, the water thus liberated acts as the solvent for the remaining material. The temperature of the solution obviously never reaches 100°C.

The test is conducted as follows:

Five tile of each make were immersed in the "solution" and at the expiration of two hours they were removed and allowed to dry at room temperature over night. This treatment was repeated five times.

Actual Freezing Test.

The tile were first immersed in water at room temperature for twenty-four hours. Taken out, drained for five minutes and put into an empty ice can, and frozen *in air* at 8° F. for ten hours. At the expiration of ten hours the tile were thawed in water at room temperature for two hours, and the test repeated one hundred times in the same manner.

Transverse Strength or Modulus of Rupture.

Tile were tested in a 20,000 pound Olsen machine. Supports of five (5) and three (3) inches were used, as the dimensions of the tile would permit.

Triangular knife edges were used and between each knife edge and the surface of the tile, strips of leather 3/16 of an inch thick were placed to take up any unevenness in the tile surfaces.

The modulus of rupture was calculated by the use of the following formula:

$$\text{Modulus of Rupture} = \frac{3\ wl}{2\ bd^2}$$

W = total "load"
l = distance between knife edges.
b = width of tile.
d = depth of tile.

Shearing Test.

The purpose of this test was to determine the relative adhesion of the various makes of tile to cement.

Tiles were first soaked in water till they were thoroughly saturated. They were then cemented together with a 50-50 cement and sand mixture. Two tile of each make, cemented together constituting one specimen. Effort was made in each case not to have the joint exceed 3/32 of an inch.

At the expiration of twenty-eight days the tile were tested. This consists in placing the tile vertically between the plates of the 20,000 lb. Olsen machine used in the modulus of rupture tests. In order to obtain a shearing effect it is necessary to apply pressure on one tile from the top, and on the other tile from the bottom. This was done by setting one of the tile on a ¾″ square cold rolled steel bar, and placing a similar bar on the top of the other tile. Leather strips were introduced between the tile and the iron to take care of the unequalities and to give an even distribution of the load.

Shearing strength is calculated by the use of the formula:

$$\text{Shearing strength} = \frac{\text{Total Load}}{\text{Surface Area of One Tile.}}$$

TABLE No. 1

SUMMARY OF RESULTS

Identification Mark	*Size*	*No. of Samples*	*% Average Absorption 5 Tile*	*Results Quenching Test—100°C (Dry Air) to Ice Water*	*Natural Freezing Test—Three Tile 100 Times*	*Artificial Freezing Test—5 Tile, 5 Times, Sodium Thiosulphate.*	*Transverse Strength Modulus of Rupture, lbs. per square inch*	*Mortar Adhesion Test, lbs. per sq. inch*
A)	6" x 6" x ¾"	50	3.4	No failures.	No failures.	No failures.	3,272	390
B)	4½" x 4½" x ½"	30	3.1	No failures.	No failures.	No failures.	2,490	185
C)	6" x 6" x ⅜"	50	21.3	5 tile crazed.	3 failed.	4 failed, 1 O. K.	865	No test.
D)	6" x 6" x ⅜"	150	1.2	5 tile crazed.	3 failed.	5 failed.	4,037	143
E)	4" x 4" x ½"	50	6.9	No failures.	1 failed, 2 O. K.	1 failed, 4 O. K.	3,281	313
F)	4½" x 4¼" x ⅜"	50	24.6	No failures.	3 failed.	3 failed, 2 O. K.	1,472	75
H)	3" x 6" x ¼"	50	13.8	No failures.	3 failed.	5 failed.	3,106	165
I)	2½" x 5½" x ½"	50	0.3	No failures.	No failures.	No failures.	3,455	216
J)	3" x 6" x ⅜"	30	13.5	1 crazed, 4 O. K.	3 failed.	5 failed.	2,383	No test.
K)	6" x 6" x ⅜"	38	14.8	No failures.	3 failed.	5 failed.	1,867	No test.
L)	2¾" x 5½" x ½"	50	0.2	1 crazed, 4 O. K.	No failures.	No failures.	3,950	166
M)	4" x 4" x ½"	50	10.2	5 tile crazed.	3 failed.	5 failed.	1,962	235
N)	4" x 4" x ½"	50	11.1	5 tile crazed.	3 failed.	5 failed.	2,015	218
O)	6" x 6" x ⅝"	50	2.8	4 crazed, 1 O. K.	3 failed.	2 failed, 3 O. K.	2,857	124
P)	6" x 6" and 3" x 6" x ⅜"	50	17.7	No failures.	3 failed.	5 failed.	1,821	143
R)	6" x 6" x ¾"	50	1.0	No failures.	No failures.	No failures.	1,821	133
V)	2¾" x 4¾" x ⅝"	50	1.2	3 crazed, 2 O. K.	No failures.	No failures.	5,750	332
W)	6" x 6" x ⅜"	50	14.3	1 crazed, 4 O. K.	3 failed.	5 failed.	1,962	110
X)	6" x 6" x ⅞"	50	10.6	No failures.	No failures.	4 O. K., 1 failed.	No test.	No test.
Y)	4" x 4" x ⅝"	25	1.8	No failures.	No test.	No failures.	No test.	No test.
Z)	6" x 6" x ⅞"	50	14.3	No failures.	No failures.	1 failed, 4 O. K.	No test.	No test.

N
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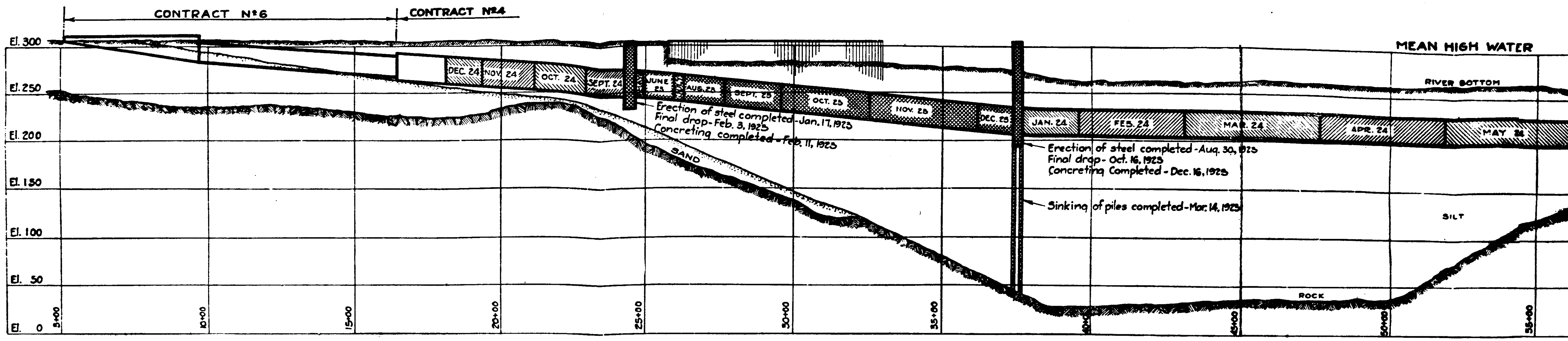
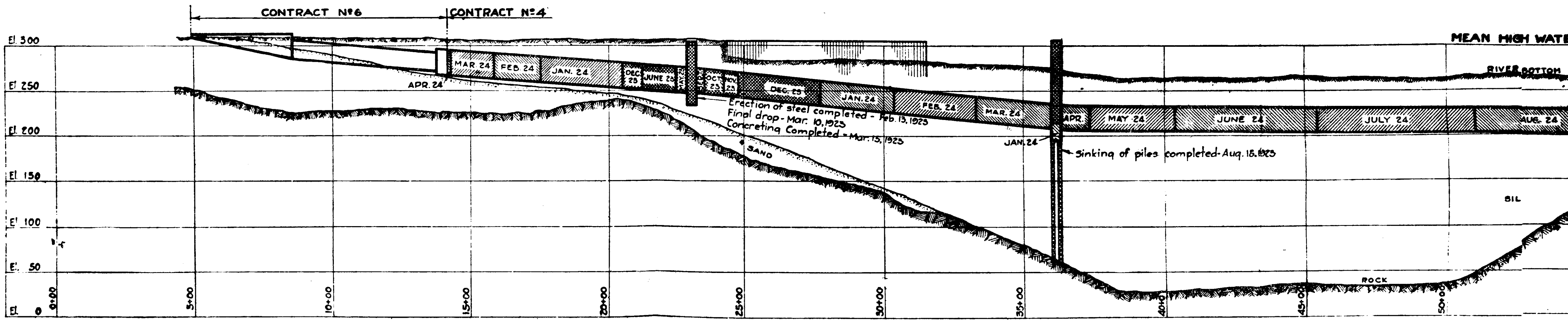


NORTH TUN

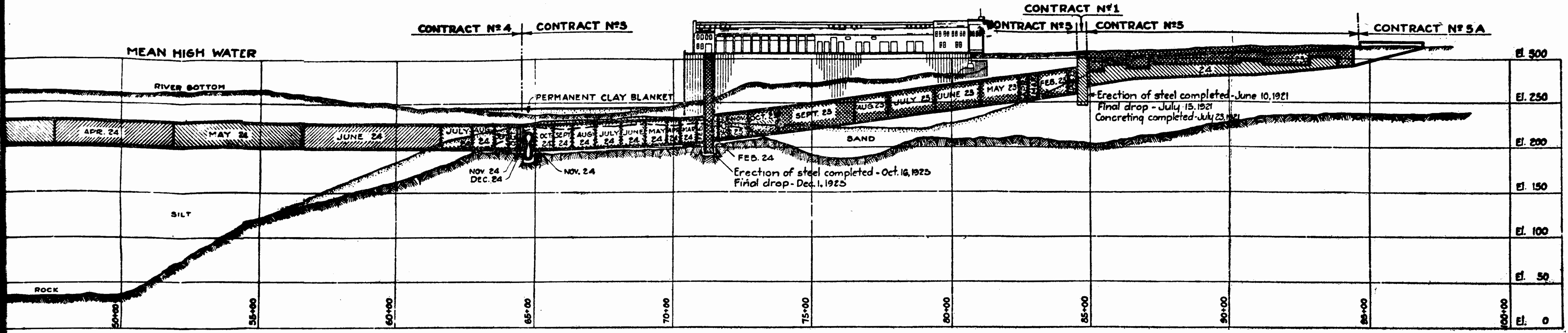


SOUTH TUN

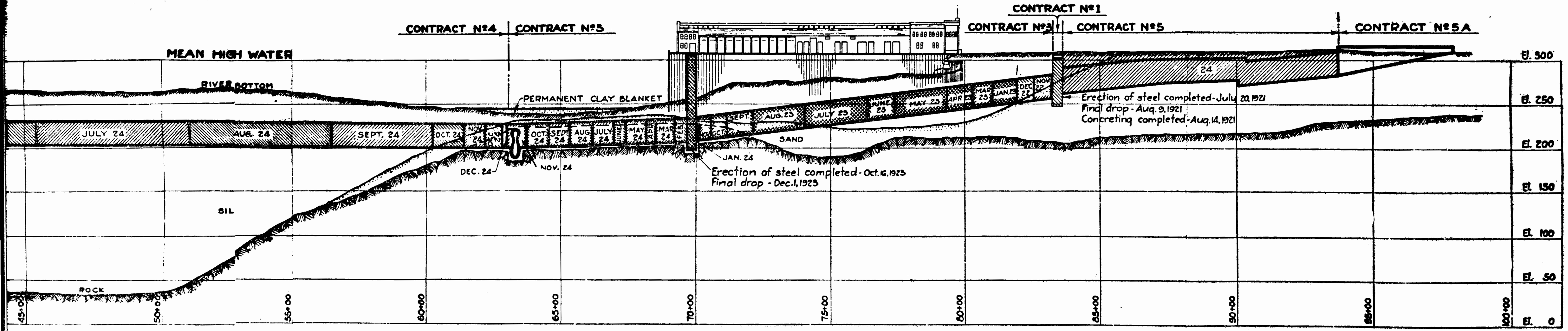
HUDSON RIVER VEH
CONSTRUCTION

SCALES: HOR. FEET VERT. FEET

PLATE Nº 15



NORTH TUNNEL



NEW YORK

SOUTH TUNNEL

RIVER VEHICULAR TUNNEL
STRUCTION PROGRESS

SCALES: HOR. FEET VERT. FEET

DECEMBER 31, 1924

NOTE:
Tunnel progress shown on Contracts Nºs 3 and 4 is exclusive of concrete lining.
Progress on Contract Nº 5 is excavation only.

NEW YORK STATE BRIDGE AND TUNNEL COMMISSION AND NEW JERSEY INTERSTATE BRIDGE AND TUNNEL COMMISSION

HUDSON RIVER VEHICULAR TUNNEL CONTRACT No. 5A

CANVASS OF BIDS RECEIVED NOVEMBER 12, 1924.

ITEM	CLASSIFICATION	UNIT	QUANTITY	RODGERS & HAGERTY INC. PRICE	RODGERS & HAGERTY INC. AMOUNT	MORANTI & RAYMOND INC. PRICE	MORANTI & RAYMOND INC. AMOUNT	FREDERICK L. CRANFORD INC. PRICE	FREDERICK L. CRANFORD INC. AMOUNT	ENGINEER'S ESTIMATE PRICE	ENGINEER'S ESTIMATE AMOUNT
2	Excavation above M.H.W.	Cu.Yd.	14500	6.00	87000.00	13.25	192125.00	14.60	211700.00	6.00	87000.00
3	Excavation below M.H.W.	"	3000	6.00	18000.00	13.25	39750.00	14.60	43800.00	8.00	24000.00
27d	Concrete	"	4400	20.00	88000.00	23.00	101200.00	24.15	106260.00	22.00	96800.00
27g	Pre-cast concrete forms	Sq.Ft.	2050	.35	717.50	.50	1025.00	.50	1025.00	.50	1025.00
29	Mortar batches used in connection with placing concrete	Bbl.	100	5.00	500.00	4.50	450.00	10.00	1000.00	5.00	500.00
34	Brick masonry	Cu.Yd.	30	50.00	1500.00	33.00	990.00	40.00	1200.00	65.00	1950.00
36	Granite curbing for tunnel roadway	Lin.Ft.	1400	4.50	6300.00	4.50	6300.00	4.00	5600.00	4.00	5600.00
37	Hollow terra cotta tile	Cu.Yd.	5	45.00	225.00	33.00	165.00	40.00	200.00	65.00	325.00
60b	Waterproofing, treated fabric laid with asphalt, 2 Ply	Sq.Yd.	1000	2.80	2800.00	1.50	1500.00	2.00	2000.00	2.00	2000.00
60c	" " " " " " 3 Ply	"	370	4.20	1554.00	2.00	740.00	2.75	1017.50	2.50	925.00
60d	" " " " " " 4 Ply	"	2000	5.60	11200.00	3.50	7000.00	3.00	6000.00	3.00	6000.00
60e	" " " " " " 5 Ply	"	10	7.00	70.00	4.00	40.00	4.00	40.00	3.50	35.00
60f	" " " " " " 6 Ply	"	800	8.40	6720.00	5.00	4000.00	4.50	3600.00	4.00	3200.00
62	Waterproofing, brick in asphalt mastic inc. 1 Ply treated fabric	Cu.Yd.	70	55.00	3850.00	55.00	3850.00	50.00	3500.00	45.00	3150.00
70a	Built up steel work and tie rods	Ton	100	120.00	12000.00	125.00	12500.00	130.00	13000.00	150.00	15000.00
70b	Bolts, castings and wrought-iron fixtures not otherwise provided for	"	1	300.00	300.00	320.00	320.00	400.00	400.00	300.00	300.00
72	Steel beams and shapes	"	23	120.00	2760.00	125.00	2875.00	130.00	2990.00	145.00	3335.00
73	Steel rods and bars	"	175	110.00	19250.00	90.00	15750.00	100.00	17500.00	100.00	17500.00
74	Wire mesh	"	3	200.00	600.00	200.00	600.00	400.00	1200.00	250.00	750.00
77a	Copper steel plates, bolts, nuts and washers	"	1.6	200.00	320.00	500.00	800.00	200.00	320.00	300.00	480.00
81	Wrought-iron or steel pipe for sub. chgs. except pipe for elec. conds.	Lb.	1500	.18	270.00	.20	300.00	.20	300.00	.20	300.00
85a	Galvanized-iron electric conduits in the tunnel, 3/4"	Lin.Ft.	760	.35	266.00	.40	304.00	.65	494.00	.50	380.00
85b	" " " " " " " 1"	"	350	.45	157.50	.50	175.00	.75	262.50	.70	245.00
85d	" " " " " " " 1½"	"	1200	.65	780.00	.60	720.00	.80	960.00	.90	1080.00
85e	" " " " " " " 2"	"	50	1.30	65.00	.75	37.50	1.50	75.00	1.10	55.00
85f	" " " " " " " 2½"	"	50	1.50	75.00	1.00	50.00	2.50	125.00	1.35	67.50
85h	" " " " " " " 4"	"	100	2.00	200.00	1.50	150.00	4.00	400.00	2.25	225.00
86a	Galvanized-iron fixtures, outlet boxes (3½"×3½"×1½")	Each	35	2.00	70.00	1.50	52.50	3.00	105.00	2.25	78.75
86b	" " " pull boxes (4×4×3)	"	5	3.00	15.00	5.00	25.00	4.00	20.00	3.50	17.50
86c	" " " " " (6×10×4)	"	6	6.00	36.00	7.00	42.00	12.00	72.00	6.00	36.00
86d	" " " " " (8×12×4)	"	6	8.00	48.00	10.00	60.00	15.00	90.00	9.00	54.00
86e	Curb guards, ladders and misc. fixtures	Lb.	2500	.25	625.00	.20	500.00	.12	300.00	.30	750.00
86g	Boxes for lights in the tunnel	Each	16	12.00	192.00	25.00	400.00	15.00	240.00	15.00	240.00
91	Furnishing cast-iron hub and spigot pipe for sub. surf. chgs. (straight pipe)	Ton	20	75.00	1500.00	100.00	2000.00	125.00	2500.00	135.00	2700.00
92	" " " " " " " " " (special castings)	"	1	175.00	175.00	200.00	200.00	250.00	250.00	300.00	300.00
95a	New C.I. manhole and catch basin fixtures etc. + castings not otherwise prov. for	"	1.6	200.00	320.00	200.00	320.00	250.00	400.00	200.00	320.00
95b	Cast-iron exhaust air ports Type A-6	Each	10	18.00	180.00	100.00	1000.00	50.00	500.00	25.00	250.00
100a	Cast-iron water discharge or other tunnel service pipe 4"	Lin.Ft.	100	1.75	175.00	1.20	120.00	2.50	250.00	2.25	225.00
100b	" " " " " " " " 6"	"	750	2.50	1875.00	1.50	1125.00	3.00	2250.00	2.75	2062.50
100c	" " " " " " " " 8"	"	225	3.25	731.25	4.00	900.00	4.00	900.00	3.50	787.50
108a	Misc. bronze fixtures	Lb.	100	1.00	100.00	1.50	150.00	1.00	100.00	1.50	150.00
108b	" brass "	"	100	1.00	100.00	1.50	150.00	1.00	100.00	1.00	100.00
110a	Tunnel ducts, single way	Duct.Ft.	5000	.30	1500.00	.30	1500.00	.30	1500.00	.25	1250.00
110f	" " 4" fibre	"	50	.30	15.00	1.00	50.00	.50	25.00	1.00	50.00
112a	Asbestos lumber ¼"	Sq.Ft.	25	1.00	25.00	.40	10.00	1.00	25.00	2.00	50.00
120b	Changing cast-iron water pipe 6"	Lin.Ft.	500	1.75	875.00	3.00	1500.00	5.00	2500.00	2.50	1250.00
122b	Changing gas pipe 6"	"	500	1.75	875.00	5.00	2500.00	5.00	2500.00	2.50	1250.00
126c	Changing W.I. steel or fibre conduits 3"	"	800	.50	400.00	1.50	1200.00	.50	400.00	.50	400.00
130c	Laying vitrified pipe sewers, 12"	"	50	3.50	175.00	5.00	250.00	6.00	300.00	4.50	225.00
130d	" " " " 15"	"	580	4.50	2610.00	6.00	3480.00	6.00	3480.00	7.00	4060.00
130e	" " " " 20"	"	270	8.50	2295.00	8.00	2160.00	7.00	1890.00	10.00	2700.00
133e	Laying cast-iron pipe sewers 12"	"	10	2.50	25.00	3.00	30.00	10.00	100.00	5.00	50.00
133f	" " " " " 16"	"	40	3.00	120.00	4.00	160.00	10.00	400.00	6.00	240.00
155	Building tight board fence	"	1400	3.00	4200.00	2.10	2940.00	2.00	2800.00	3.00	4200.00
156	" temporary wooden rail fence	"	700	1.00	700.00	1.00	700.00	1.00	700.00	1.00	700.00
164a	Restoration of granite block pavement	Sq.Yd.	50	5.00	250.00	3.00	150.00	5.00	250.00	6.00	300.00
164c	Temporary restoration and maintenance of granite block pavement	"	1500	4.00	6000.00	2.50	3750.00	4.00	6000.00	4.50	6750.00
165a	Restoration of sidewalk	"	300	3.00	900.00	3.00	900.00	3.00	900.00	4.00	1200.00
165b	Temporary restoration and maintenance of sidewalks	"	1200	3.00	3600.00	2.50	3000.00	2.00	2400.00	2.00	2400.00
166	Restoration of curbing	Lin.Ft.	500	1.00	500.00	1.50	750.00	3.00	1500.00	1.00	500.00
170	New granite block pavement	Sq.Yd.	250	8.00	2000.00	4.00	1000.00	6.00	1500.00	8.00	2000.00
171	New cement sidewalk	"	500	3.00	1500.00	3.60	1800.00	3.00	1500.00	4.00	2000.00
172	New granite curbing	Lin.Ft.	250	4.50	1125.00	4.00	1000.00	7.50	1875.00	4.00	1000.00
		TOTALS			301,312.25		429,591.00		465,591.00		312,873.75

PLATE No. 17

NEW YORK STATE BRIDGE AND TUNNEL COMMISSION AND NEW JERSEY INTERSTATE BRIDGE AND TUNNEL COMMISSION

HUDSON RIVER VEHICULAR TUNNEL CONTRACT No. 6

CANVASS OF BIDS RECEIVED NOVEMBER 12, 1924.

ITEM	CLASSIFICATION	UNIT	QUANTITY	BOOTH & FLINN LTD. PRICE	BOOTH & FLINN LTD. AMOUNT	RODGERS & HAGERTY INC. PRICE	RODGERS & HAGERTY INC. AMOUNT	FREDERICK L. CRANFORD INC. PRICE	FREDERICK L. CRANFORD INC. AMOUNT	FREDERICK SNARE CORPORATION. PRICE	FREDERICK SNARE CORPORATION. AMOUNT	ENGINEER'S ESTIMATE PRICE	ENGINEER'S ESTIMATE AMOUNT
2	Excavation above M.H.W.	Cu.Yd	26500	10.00	265000.00	11.00	291500.00	25.00	662500.00	25.00	662500.00	6.00	159000.00
3	Excavation below M.H.W.	"	58500	10.00	585000.00	11.50	672750.00	25.00	1462500.00	25.00	1462500.00	15.00	877500.00
5	Caisson excavation	"	1885	110.00	207350.00	135.00	254475.00	150.00	282750.00	80.00	150800.00	145.00	273325.00
27d	Concrete	"	25250	20.00	505000.00	24.00	606000.00	27.80	701950.00	35.00	883750.00	22.00	555500.00
27g	Pre-cast concrete forms	Sq.Ft.	35700	.60	21420.00	.40	14280.00	.50	17850.00	1.00	35700.00	.50	17850.00
29	Mortar batches used in connection with placing concrete	Bbl.	1000	4.00	4000.00	5.00	5000.00	8.00	8000.00	6.00	6000.00	5.00	5000.00
34	Brick masonry	Cu.Yd	110	50.00	5500.00	65.00	7150.00	40.00	4400.00	45.00	4950.00	65.00	7150.00
36	Granite curbing for tunnel roadway	Lin.Ft.	4220	5.00	21100.00	4.50	18990.00	4.50	18990.00	6.00	25320.00	3.75	15825.00
37	Hollow terra cotta tile	Cu.Yd	20	28.00	560.00	50.00	1000.00	40.00	800.00	40.00	800.00	60.00	1200.00
53	Timber piles	Lin.Ft.	17500	2.00	35000.00	.80	14000.00	2.00	35000.00	1.50	26250.00	1.50	26250.00
59	Timber cradle to support sewers	M.FBM.	15	140.00	2100.00	120.00	1800.00	250.00	3750.00	150.00	2250.00	130.00	1950.00
60b	Waterproofing, treated fabric laid with asphalt, 2 Ply	Sq.Yd	1400	1.60	2240.00	2.80	3920.00	2.00	2800.00	3.00	4200.00	2.00	2800.00
60c	" " " " " " 3 Ply	"	2430	2.40	5832.00	4.20	10206.00	2.50	6075.00	3.50	8505.00	2.50	6075.00
60d	" " " " " " 4 Ply	"	11400	3.20	36480.00	5.60	63840.00	3.00	34200.00	4.50	51300.00	3.00	34200.00
60e	" " " " " " 5 Ply	"	50	4.50	225.00	7.00	350.00	4.00	200.00	5.00	250.00	3.50	175.00
60f	" " " " " " 6 Ply	"	1900	5.10	9690.00	8.50	16150.00	4.00	7600.00	5.30	10070.00	4.00	7600.00
62	Waterproofing, brick in asphalt mastic inc. 1 Ply treated fabric	Cu.Yd	1885	60.00	113100.00	60.00	113100.00	55.00	103675.00	70.00	131950.00	45.00	84825.00
70a	Built-up steel work and tie rods	Ton	3000	150.00	450000.00	116.00	348000.00	175.00	525000.00	200.00	600000.00	140.00	420000.00
70b	Bolts, castings and wrought-iron fixtures not otherwise pro. for	"	3	350.00	1050.00	400.00	1200.00	400.00	1200.00	600.00	1800.00	250.00	750.00
72	Steel beams and shapes	"	545	150.00	81750.00	116.00	63220.00	175.00	95375.00	200.00	109000.00	135.00	73575.00
73	Steel rods and bars	"	385	200.00	77000.00	110.00	42350.00	100.00	38500.00	120.00	46200.00	100.00	38500.00
74	Wire mesh	"	25	300.00	7500.00	250.00	6250.00	400.00	10000.00	300.00	7500.00	250.00	6250.00
75f	Air duct manhole frames with covers	Each	16	150.00	2400.00	200.00	3200.00	400.00	6400.00	150.00	2400.00	100.00	1600.00
75g	Furnishing new riveted steel pipe sewers	Ton	335	150.00	50250.00	120.00	40200.00	200.00	67000.00	180.00	60300.00	250.00	83750.00
77a	Copper steel plates, bolts, nuts and washers	"	19	200.00	3800.00	200.00	3800.00	400.00	7600.00	500.00	9500.00	250.00	4750.00
81	Wrought-iron or steel pipe for sub. chg's. except pipe for elec. cond.	Lb.	2000	.15	300.00	.20	400.00	.15	300.00	.30	600.00	.20	400.00
85a	Galvanized iron electric conduits in the tunnel, 3/4"	Lin.Ft.	5150	.25	1287.50	.45	2317.50	.50	2575.00	.60	3090.00	.45	2317.50
85b	" " " " " " " 1"	"	2280	.35	798.00	.60	1368.00	.60	1368.00	.90	2052.00	.60	1368.00
85d	" " " " " " " 1½"	"	11520	.60	6912.00	.80	9216.00	.90	10368.00	1.20	13824.00	.80	9216.00
85e	" " " " " " " 2"	"	1150	1.00	1150.00	1.30	1495.00	1.00	1150.00	1.50	1725.00	1.00	1150.00
85f	" " " " " " " 2½"	"	100	1.10	110.00	1.50	150.00	2.50	250.00	2.25	225.00	1.25	125.00
85g	" " " " " " " 3"	"	100	1.70	170.00	1.60	160.00	3.00	300.00	3.00	300.00	1.50	150.00
85h	" " " " " " " 4"	"	525	2.25	1181.25	2.00	1050.00	4.00	2100.00	4.00	2100.00	2.00	1050.00
86a	Galvanized iron fixtures, outlet boxes 3½"×3½"×1½"	Each	35	2.50	87.50	2.00	70.00	3.00	105.00	6.00	210.00	2.00	70.00
86b	Pull boxes 4"×4"×3"	"	55	3.00	165.00	3.00	165.00	4.00	220.00	15.00	825.00	3.00	165.00
86c	Pull boxes 6"×10"×4"	"	30	6.00	180.00	6.00	180.00	10.00	300.00	20.00	600.00	5.00	150.00
86d	Pull boxes 8×12×4	"	55	8.50	467.50	8.00	440.00	15.00	825.00	30.00	1650.00	8.00	440.00
86e	Curb guards, ladders and misc fixtures	Lbs.	8500	.20	1700.00	.25	2125.00	.20	1700.00	.50	4250.00	.30	2550.00
86f	Pull boxes 12×24×6	Each	10	17.00	170.00	20.00	200.00	15.00	150.00	70.00	700.00	12.00	120.00
86g	Boxes for lights in the tunnel	"	140	10.00	1400.00	12.00	1680.00	15.00	2100.00	30.00	4200.00	13.00	1820.00
91	Furnishing cast iron hub and spigot pipe for surf. chg's. (Straight pipe)	Ton	60	100.00	6000.00	80.00	4800.00	100.00	6000.00	120.00	7200.00	125.00	7500.00
92	" " " " " " " " " " (Special castings)	"	6	200.00	1200.00	200.00	1200.00	250.00	1500.00	250.00	1500.00	200.00	1200.00
95a	New C.I. manhole and catch basin fixtures etc.	"	5	160.00	800.00	200.00	1000.00	250.00	1250.00	400.00	2000.00	200.00	1000.00
95b	Cast-iron exhaust air ports Type A-6	Each	76	20.00	1520.00	20.00	1520.00	50.00	3800.00	120.00	9120.00	20.00	1520.00
95c	Cast-iron exhaust air ports Type E-3	"	106	26.00	2756.00	25.00	2650.00	40.00	4240.00	100.00	10600.00	25.00	2650.00
100a	Cast-iron water discharge or other tunnel service pipe, 4"	Lin.Ft.	270	1.60	432.00	1.75	472.50	2.50	675.00	3.00	810.00	2.00	540.00
100b	" " " " " " " " " 6"	"	3150	2.40	7560.00	2.50	7875.00	3.00	9450.00	3.50	11025.00	2.50	7875.00
100c	" " " " " " " " " 8"	"	470	3.00	1410.00	3.25	1527.50	4.00	1880.00	4.00	1880.00	3.25	1527.50
100d	" " " " " " " " " 10"	"	290	4.00	1160.00	4.00	1160.00	5.00	1450.00	5.00	1450.00	4.00	1160.00
100e	" " " " " " " " " 12"	"	50	5.00	250.00	5.00	250.00	7.00	350.00	6.00	300.00	5.00	250.00
108a	Misc. bronze fixtures	Lb.	500	1.25	625.00	1.00	500.00	1.00	500.00	2.00	1000.00	1.25	625.00
108b	Misc brass fixtures	"	1000	1.25	1250.00	1.00	1000.00	1.00	1000.00	2.00	2000.00	.75	750.00
109a	Sheet lead for waterproofing and flashing	"	24200	.20	4840.00	.50	12100.00	.40	9680.00	.25	6050.00	.25	6050.00
110a	Tunnel ducts, single way	Duct Ft.	26570	.30	7971.00	.30	7971.00	.30	7971.00	.35	9299.50	.25	6642.50
110b	" " 2 way	"	100	.30	30.00	.30	30.00	.30	30.00	.35	35.00	.25	25.00
110c	" " 3 "	"	600	.30	180.00	.30	180.00	.30	180.00	.35	210.00	.25	150.00
110d	" " 4 "	"	100	.30	30.00	.30	30.00	.30	30.00	.35	35.00	.25	25.00
110e	" " 6 "	"	1700	.35	595.00	.30	510.00	.30	510.00	.35	595.00	.25	425.00
110f	" " 4" fibre	"	3200	.30	960.00	.30	960.00	.40	1280.00	.50	1600.00	.60	1920.00
112a	Asbestos lumber ¼"	Sq.Ft.	450	.50	225.00	1.00	450.00	1.00	450.00	2.00	900.00	1.25	562.50
120a	Changing cast-iron water pipe 4" or under	Lin.Ft.	500	.90	450.00	2.00	1000.00	2.00	1000.00	2.50	1250.00	2.00	1000.00
120b	" " " " " 6"	"	1150	1.75	2012.50	2.50	2875.00	3.00	3450.00	2.50	2875.00	2.50	2875.00
120d	" " " " " 10"	"	860	2.50	2150.00	3.00	2580.00	4.00	3440.00	3.50	3010.00	3.00	2580.00
122a	Changing gas pipe (not new pipe) 4"	"	250	.90	225.00	2.00	500.00	4.00	1000.00	2.50	625.00	2.00	500.00
122b	" " " " " " 6"	"	50	1.75	87.50	2.50	125.00	5.00	250.00	2.50	125.00	2.50	125.00
126a	Changing creosted wood conduits 2"	"	2300	1.50	3450.00	.60	1380.00	.40	920.00	1.00	2300.00	.60	1380.00
130b	Laying vitrified pipe sewers 6" pipe	"	100	1.00	100.00	2.00	200.00	4.50	450.00	3.00	300.00	2.00	200.00
130c	" " " " 12" "	"	50	2.00	100.00	4.00	200.00	6.00	300.00	4.00	200.00	4.00	200.00
130f	" " " " 18" "	"	600	3.00	1800.00	6.00	3600.00	6.50	3900.00	5.00	3000.00	7.00	4200.00
133b	Laying cast-iron pipe sewers 6" pipe	"	100	1.50	150.00	2.50	250.00	5.00	500.00	3.50	350.00	2.00	200.00
133c	" " " " " 8" "	"	300	1.75	525.00	3.00	900.00	6.00	1800.00	3.50	1050.00	2.50	750.00
134a	Changing steel pipe sewers 60"	"	630	5.00	3150.00	6.00	3780.00	30.00	18900.00	20.00	12600.00	15.00	9450.00
134b	" " " " 66"	"	800	10.00	8000.00	7.25	5800.00	30.00	24000.00	20.00	16000.00	15.00	12000.00
134c	" " " " 96"	"	250	15.00	3750.00	9.75	2437.50	50.00	12500.00	24.00	6000.00	30.00	7500.00
155	Building tight board fence	"	2400	2.50	6000.00	3.50	8400.00	3.00	7200.00	3.00	7200.00	3.00	7200.00
164a	Restoration of stone block pavement	Sq.Yd.	500	3.00	1500.00	4.50	2250.00	5.00	2500.00	6.00	3000.00	3.00	1500.00
166	Restoration of curbing	Lin.Ft.	100	3.00	300.00	1.00	100.00	2.00	200.00	2.50	250.00	1.00	100.00
		TOTAL			2,582,969.75		2,706,311.00		4,262,462.00		4,467,890.50		2,820,649.00