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THE NEW TERMINAL STATION AND FERRYHOUSE OF THE DELAWARE, LACKAWANNA & WESTERN R. R. AT HOBOKEN, N. J.

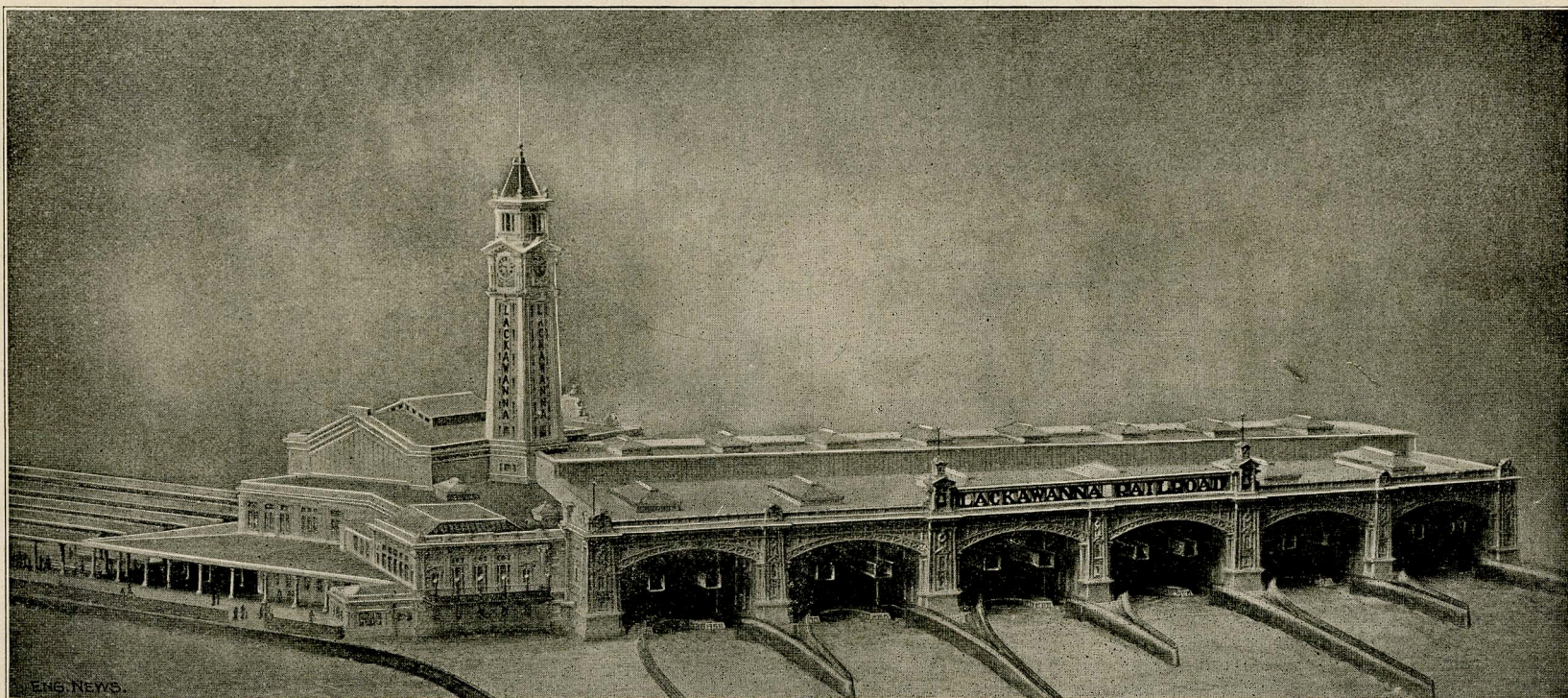
By Charles C. Hurlbut.*

The new terminal and ferryhouse of the Lackawanna Railroad at Hoboken, N. J., now in course of construction, is a fireproof structure erected entirely over water and possesses some features unique in buildings of this class. The architectural effect of the new terminal may be gathered from the adjoining halftone

sary to design the new building for construction in six consecutive sections, each of which could be opened for traffic before starting the succeeding one. A fire on Aug. 8, 1905, which totally destroyed the old terminal and ferryhouse, somewhat altered this plan, however, and the temporary buildings now in use were so placed as to facilitate the construction as far as possible. An elevated-track station was considered but rejected as impracticable owing largely to the steep grades that would be introduced by the position of the railroad yards and the tunnel

were the main controlling factors in the plan of the ferryhouse portion of the terminal.

The requirements of the railroad station were: Ample waiting-room facilities for passengers waiting for trains and for boats, including provision for housing safely as many as 20,000 people at one time, which might become necessary in the event of the disability of the ferry for an hour or more in the morning rush hours; Restaurant, lunch-room and kitchen; Storerooms for the dining car and commissary departments; Offices for the division superintendent, train



GENERAL VIEW OF NEW TERMINAL OF DELAWARE, LACKAWANNA & WESTERN R. R. AT HOBOKEN, N. J.

(From photograph of a model.)

view, the photograph of a complete model of the structure; the view is from the southeast, thus showing the ferry front of the building.

The chief points of interest from an engineering and architectural standpoint are the concrete foundation supported on piles; the steel and concrete construction of the superstructure, designed with a special view to the resistance to shock and unequal settlement; the very extensive use of copper as an exterior finish and its mode of application, and the methods of erection necessitated by the conditions of traffic.

GENERAL PLAN.

The plan was controlled to a large extent by local conditions. About 600 ft. of the water front was available, bounded on the north by the steamship piers of the Hamburg American Line. As a large part of this frontage was occupied by the old terminal, through which about 100,000 people a day were passing, it was neces-

sary to design the new building for construction in six consecutive sections, each of which could be opened for traffic before starting the succeeding one.

The number of passengers carried by the three ferries entering the terminal in the first six months of 1906 was 17,200,000, which means a daily average of 94,300. As the number carried on Sundays and holidays, however, is much less than on week-days, the week-day average is something over 100,000. Of this number something less than half are railway passengers, and the others are distributed by the trolley lines terminating at the station or pass direct to the street. The great bulk of this traffic is concentrated into a few hours in the morning and late afternoon. The ferryhouse provides for three separate ferry-lines, each with two slips, equipped for double-deck boats. To separate and prevent congestion of these many lines of traffic, to provide for rapid loading and unloading of boats, to make the entrance and exit of ferry-passengers as short and direct as possible, and (not least) to prevent "beating the ferry"

dispatchers, ferry superintendent, baggage master, auditor and other officials; besides a barber shop, toilets, hospital room and the other usual adjuncts of a terminal railroad station.

The disposition of space to meet these various requirements is clearly shown on the general plans reproduced in Fig. 2. Eastbound passengers from trains pass from the train concourse either (1) up a 10% incline just south of the Main Waiting Room, to the ferry concourse on the second floor and thence to the upper deck of the boats, or (2) through the east-bound waiting-room and team concourse to the lower deck of boats. Subsidiary waiting-rooms are provided on the first floor, for the convenience of passengers, between the ferry slips. Eastbound ferry passengers enter the ferry waiting-room and pass direct to the boats, or by means of stairs to the ferry concourse. West-bound passengers pass direct to the street by practically straight exits from the lower deck of boats; or, from the upper deck, enter the

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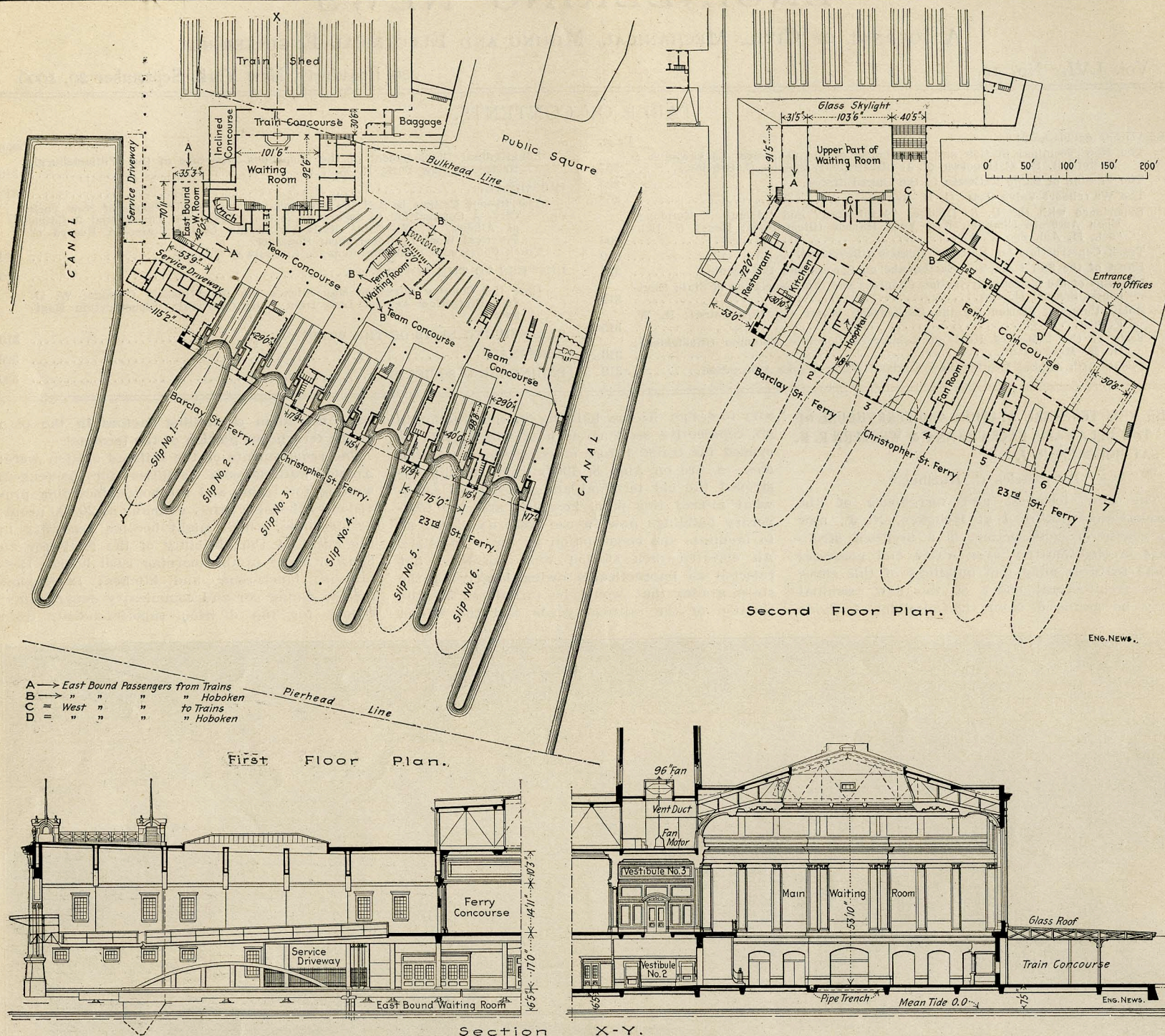


FIG. 2. FIRST AND SECOND FLOOR PLANS, AND LONGITUDINAL SECTION; LACKAWANNA TERMINAL STATION AT HOBOKEN, N. J.
(Note.—Upper Deck Landing Bridge Shown in Longitudinal Section is old type. See Fig. 13 for drawing of bridge actually used.)

ferry concourse, and thence pass to the street by easy stairways. Passengers to the trains go to the trainshed by way of the westbound concourse, which leads off the Ferry Concourse along the north of the main waiting room and terminates in a stairway 40 ft. wide, or pass into the main waiting-room by a marble staircase. Provision is made in the plan for a future arcade from the ferry concourse to the trolley terminus about 200 ft. away.

The main waiting-room for westbound (out-going) train passengers is 90 ft. x 100 ft. in plan, and 53 ft. 10 ins. high, with large windows on all sides and a large skylight overhead. The ferry concourse is 70 ft. wide, 470 ft. long and 28 ft. 5 ins. high, lighted by large skylights. This concourse is flanked by rows of twin columns supporting deep beams which divide the main part of the concourse into seven panels, forming its most distinctive decorative feature. The restaurant is 72 ft. x 53 ft. The total river elevation is 566 ft. 2½ ins. long. The train concourse is 307 ft. long and provides for fourteen tracks. The baggage room (for Hoboken baggage only, New York baggage being checked at the New York ferry terminals) is practically a separate building and opens on the train concourse.

The train concourse is entirely covered with a

roof of wire glass supported on steel trusses and purlins. The sidewalk along the entire street front of the building is covered by a marquise of similar construction.

A two-story building to serve as immigrant station and as depot for the supply of Pullman cars is located at the head of the short canal just south of the main terminal. This building is indicated in the Second Floor Plan (in Fig. 2). The Service Driveway and the Immigrant Track are arranged with reference to the location of this building.

Structural and Ornamental Design.

GRADES.—The floor level of the ferryhouse was fixed by the height of the first deck of the boats above the water under ordinary loading, namely 6 ft. 5 ins., and that level was therefore adopted as the general level of the ferryhouse floor. The level of the railroad station was determined by the height of the tracks, and that floor was accordingly fixed at 7 ft. 5 ins. above mean tide. The change from one grade to another is made by easy inclines. The level of the tops of piers is in all cases 3 ft. 2 ins. above mean tide. This is 8 ins. above high tide and as close to the floor construction as was possible and allow the necessary spread for the column bases.

ARCHITECTURAL DESIGN.—The most notable feature of the building as one approaches

from the river is the clock tower, which rises to a height of 203 ft. above mean tide to the base of the flagpole. The six ferry slips are spanned by arches, supported by ornamental piers, as shown in the view on the preceding page. The base of the piers and also the base of the restaurant wing is of faced concrete; above this level the entire structure, including the tower, is covered with copper-work. The west or street elevation of the ferryhouse portion has five bays, surmounted by pediments, and is also of copper. The baggage room building and the first story of the north elevation of the railroad station are of Indiana limestone with copper-work above. The ornamental details of the copper-work were carefully studied with a view to preserve the character of the material and give a "metallic feeling" to the design. Details and moldings usual in stonework cannot be copied successfully in sheet-metal without modification, and all appearance of an attempt to imitate stone or other material was carefully avoided. The interiors will be finished for the most part in plaster and while not ornate in treatment will follow the modern French school. The first story walls of the main waiting-room are of buff limestone.

STRUCTURAL DESIGN.—The entire terminal building with the exception of the baggage room

wing is built over water of a depth of about 20 ft., overlying from 70 to 75 ft. of mud. Under the mud is a bed of sand and gravel of varying thickness, and rock is encountered at a depth of from 110 to 120 ft. below mean tide. The general requirements of the case called for a permanent, fireproof structure, sufficiently flexible to permit of slight inequality of settlement without serious damage and yet sufficiently rigid to withstand the shocks of the ferryboats, and as light as possible. The type decided upon was a riveted steel framework enclosed entirely in concrete. All the stresses are figured as taken up by the steel.

FOUNDATIONS.—The typical foundation is clearly shown in the vertical section in Fig. 3. Each column is supported on a group of from 9 to 25 piles of long leaf yellow pine from 80 to 90 ft. long. The pile loading is about 8 tons maximum. The piles are cut off at low water and capped with 12 × 12-in. timbers, upon which is laid a solid flooring of 12 × 12-in. alternating with 12 × 8-in. timbers. As the average height of tide (between high and low water) is 5 ft., the woodwork is entirely submerged about two-thirds of the time and is always wet, so that the danger of decay is eliminated. In the waters of the North River it is unnecessary to take precautions against the teredo or limnoria, as the presence of these pests has not been discovered in any piles driven in these waters within the last twenty years. This statement is based on the experience of the engineering departments of the Delaware, Lackawanna & Western R. R. and the New York City Department of Docks & Ferries; the fact is explained by the presence of sewage in the water. In each grillage as described above, two or more timbers of each course are continuous through two or more footings, as shown in the plan in Fig. 3. The footings are therefore securely tied together in two directions, effectually preventing any lateral displacement of any individual footing. The whole

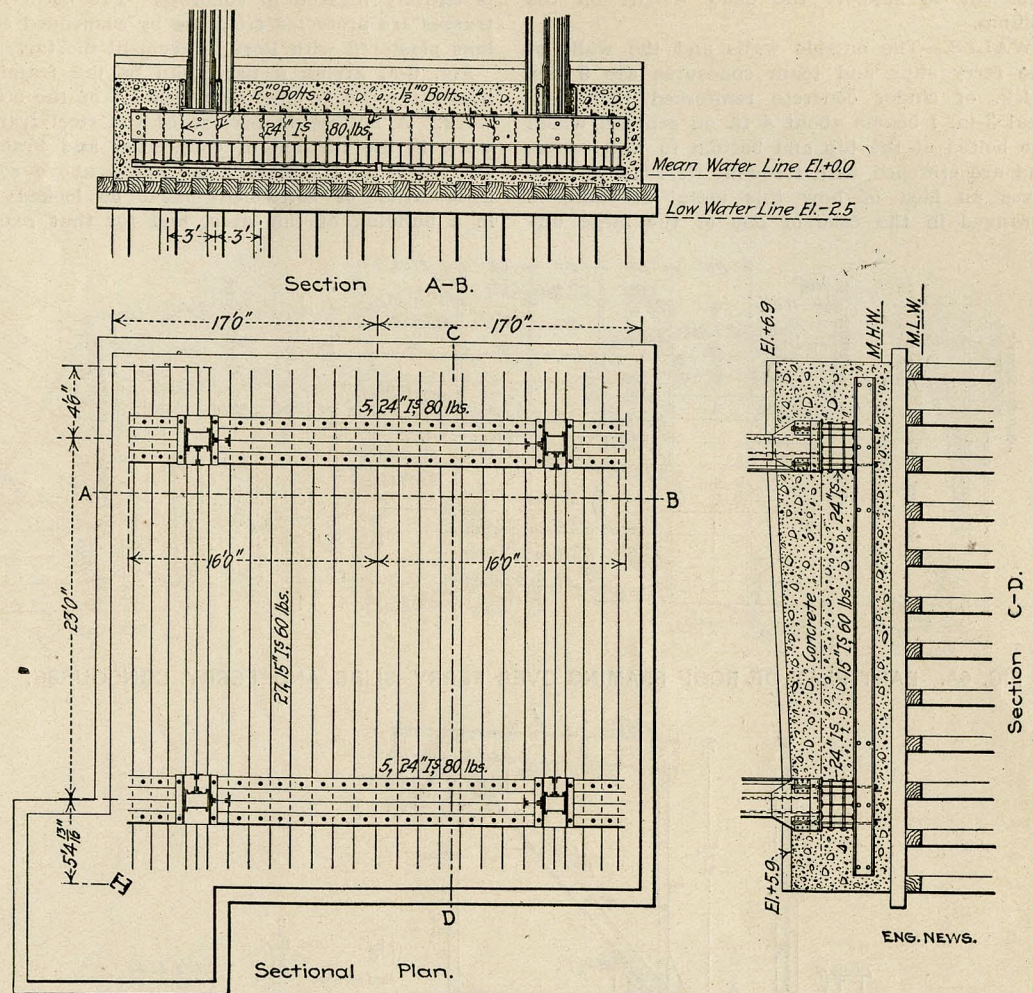
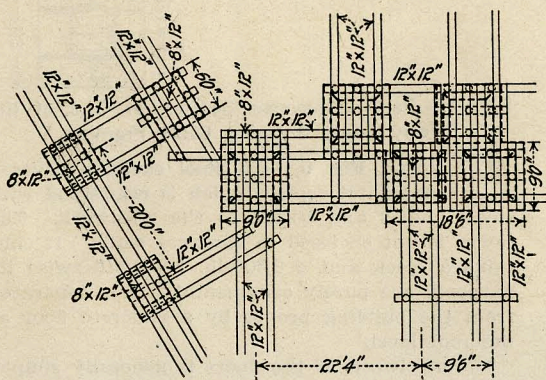
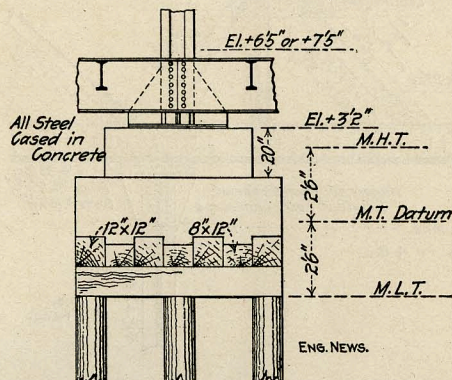


FIG. 4. FOUNDATION OF TOWER.



Piling and Grillage.



Column Foundation.

FIG. 3. TYPICAL COLUMN FOUNDATION, AND PART PLAN OF PILING AND GRILLAGE, SHOWING METHOD OF TYING TOGETHER THE PIERS.

timber structure is securely bolted together. On the platforms described were built concrete piers which were leveled off for the columns 3.13 ft. above mean tide. Anchor bolts were built in to secure the columns, and under the heavier columns the concrete piers were reinforced with grillage of steel beams.

The foundation of the tower, Fig. 4, differs from this arrangement because the tower was designed to rest on a single foundation block in place of four separate footings, in order to avoid all risk of unequal settlement. The area covered by the tower foundation is closely piled and a two-course timber grillage built over the piles. The concrete pier constructed on this grillage extends to within 4 ins. of the finished floor, or 6 ft. 1 in. above mean tide; it encloses a steel grillage of two courses of I-beams, 15 and 24-in., securely tied together by steel angles and bolts. The four tower legs rest on the upper course of grillage beams, the column footing thus being imbedded in the foundation concrete.

All foundation piers (except that of the tower) are formed with offsets or shoulders around the outside, adapted to serve as a footing for hydraulic jacks to allow of raising the columns in

case of undue settlement; for the same purpose inverted stiffeners were placed above the girder connections of the first floor, strong enough to take the entire dead load of the column above the first floor, except where the girder connection itself was strong enough to take this load. After placing the steelwork of the first section the column footings settled about $\frac{3}{4}$ -in., and after the concrete of walls, floors and roof was placed a further settlement was found, ranging from $\frac{1}{4}$ -in. to $2\frac{1}{4}$ ins. The tower foundations settled $\frac{3}{4}$ -in. after placing the concrete pier; this was taken up with steel plates before setting the steelwork. After the erection of the steelwork a further settlement of $\frac{1}{8}$ -in. was found, uniform over the whole area of the tower base.

The general type of the foundations was developed by the writer, with the cooperation of Mr. E. W. Stern, the consulting engineer of the work. The pile loading was fixed by the engineering department of the railroad company, which also worked out the plans of the foundations in detail and carried out their construction, under Mr. Lincoln Bush, Chief Engineer.

FLOORS AND ROOFS.—The floors and roofs throughout the building are of reinforced con-

crete, Columbian type, supported on steel beams and girders with riveted connections. The beams are spaced from 5 ft. to 7 ft. on centers. The first floor is of stone concrete and the second floor and roof are of cinder concrete, both being mixed in the proportion 1:2½:5. The first floor of the ferryhouse and the service driveway are designed for a maximum concentrated load consisting of a truck weighing 15 tons on a 5 ft. × 10 ft. base. Other floors are designed for live loads of from 90 to 120 lbs. per sq. ft. It will be noted from the drawings that the first-floor girders are riveted to the columns and do not rest on the concrete footings, and as stated above these connections are in all cases made

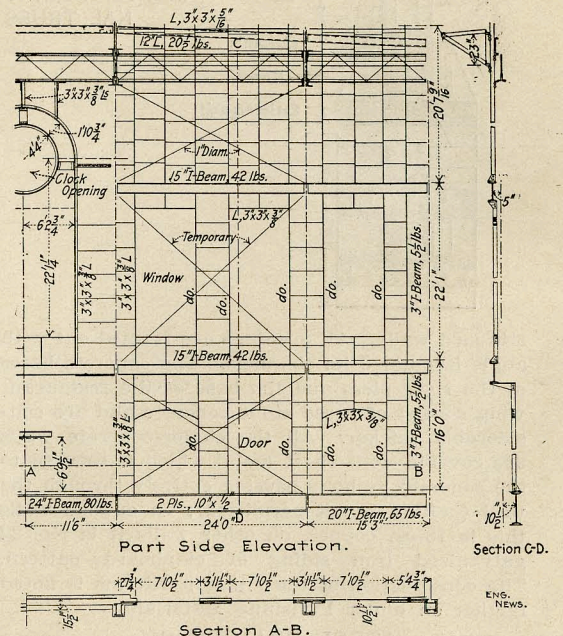
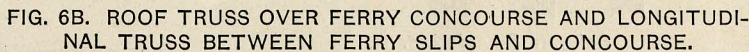
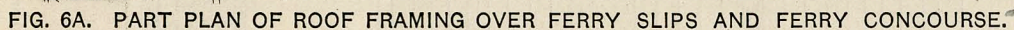


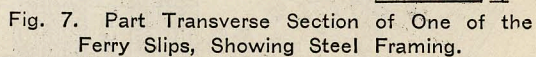
Fig. 5. Steel Studding of West Wall of Train Waiting-Room.

(This is typical of the wall-framing throughout the Terminal.)

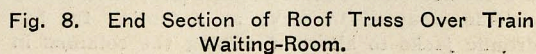
Fig. 6-a, giving a part plan of the framing, illustrates the general arrangement of the steel-work. A noticeable feature of the steel framework is the method of connection and bracing of trusses and girders. As stated above some irregularity of settlement must be looked for in a building of this area, and for that reason



Except in the tower, no diagonal framing is used in the walls, in order to carry out this scheme of flexibility. But abundant provision was made for temporary sway-bracing; connection plates for 1-in. diagonal rods riveted to the columns were provided (see Fig. 7) instead of letting the bracing during erection rely on make-shift connections. Sway-rods of 1-in. round steel were called for as part of the material, and the drawings called for connection-plates in a sufficient number of panels to make certain of early bracing no matter where the erection might be started.



The steelwork of the floors is generally simple. The special connections of the first floor girders



have already been re-
marked upon. Another
feature worth noting oc-
curs in the floor of the
ferry-concourse, where
long spans had to be
bridged, as the team-con-
course beneath could not
be impeded by columns.
Since head-room in the
team-concourse was an
important matter, it was
necessary to contrive
girders of the required
span with a minimum
depth. This was done by
using a pin-connected
cantilever construction
for the main plate-girder
which runs longitudinally
under the ferry-concourse
floor. Fig. 10 shows the
construction used. This
girder runs along the
middle line of the ferry-concourse. The correspond-
ing girders along the east line of the ferry-con-
course, which have equally wide column spacing,
do not require this unusual device, as they could
be hung from the roof trusses above by a sus-
pender, which halves the girder span (see Fig. 6-b).

FINISHING MATERIALS.

Wood will be used very sparingly throughout the building, being limited to trim and the floors of offices.

FLOORING.—The principal rooms, including main waiting room, ferry waiting room, restaurant, lunch room, kitchen, service room, barber shop and the west bound and main ferry concourses, are floored with terrazzo. In the construction of these floors special attention is given to reducing the danger from cracks to a minimum. The fireproof floor slab finishes 5 ins. from the finished floor. Over this is laid one inch of dry sand, above which is spread a layer of tar paper, and above the paper 2½ ins. of cinder concrete (1:3:6 mix). The top 1½ ins. is a terrazzo wearing surface of cement and Italian marble chips ground and rubbed to a true polished surface. The terrazzo is laid in patterns of various colors determined by the kind of marble used, white and serpentine predominating. These rooms are also provided with marble bases.

The entire area of the inclined concourse is covered with Mason safety treads set in Portland cement. Provision is made for their removal by setting in cast-iron blocks to which the tread is screwed. The team-concourse, comprising almost the entire first floor of the ferry house, is vitrified brick set in asphalt. This paving was adopted after a thorough investigation by the railroad company of granite, wood and asphalt blocks, sheet asphalt, plank and other floors, and was selected because of its great wearing qualities and freedom from slipperiness. The train-concourse floor and some of the storeroom floors are cement. The east-bound waiting-room and the commissary receiving room have asphalt floors of specially selected rock asphalt. The baggage-room has a rock asphalt floor in which is imbedded a cast-iron grill of hexagonal pattern. All asphalt floors are laid under a five-year guarantee. The ferry waiting-room and the piers between the ferry slips are specified of magnesium composition. All office floors are of maple.

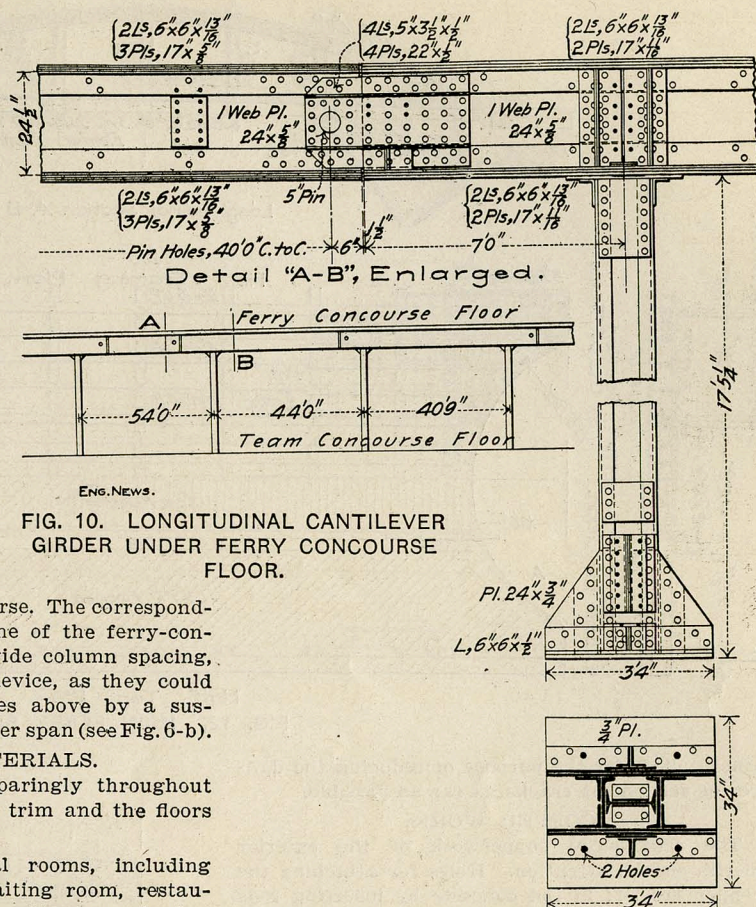


FIG. 10. LONGITUDINAL CANTILEVER GIRDER UNDER FERRY CONCOURSE FLOOR.

ROOFING.—All flat roofs are five-ply tar and gravel, the tar being best straight run American coal-tar pitch. The roofs are guaranteed for ten years by a security company's bond.

DAMP-PROOFING.—To prevent moisture arising from the river and working through the floors, all enclosed rooms of the first floor are protected with a damp-proof course of three-ply felt and coal-tar pitch laid between the fireproof floor slab and the fill. A similar course is provided under the kitchen and toilets of second story and on the inclined plane.

PARTITIONS.—All partitions are constructed of flat metal studding and wire lath. They are of three types: (A) 2-in. solid plaster with one thickness of lath imbedded; (B) 4-in. hollow partition having 2-in. air space, and (C) partitions similar to B but filled solid with cinder concrete. Type B predominates throughout the job. Type C is used where a partition of extra strength is required, as the walls of concourses or where there is a special fire hazard as in the case of store-rooms.

PLASTERING AND FURRING.—All finished rooms are plastered with three coats of patent plaster applied on galvanized metal lath. The furring bars are in all cases bolted to their supports, the only tying allowed being in the attachment of lath. Suspended ceilings are supported on extra strong bolted hangers. In the case of wall furring, bolts are built into the concrete, to which are secured horizontal 1 x ¼-in. bars, 4 ft. c. to c. The ⅞-in. channel furring bars, 12 in. c. to c., are bolted to these bars with angle clips and ¼-in. bolts. In the ferry-concourse, the wall furring is divided into separate panels and the joints covered by pilasters, each cast in one piece.

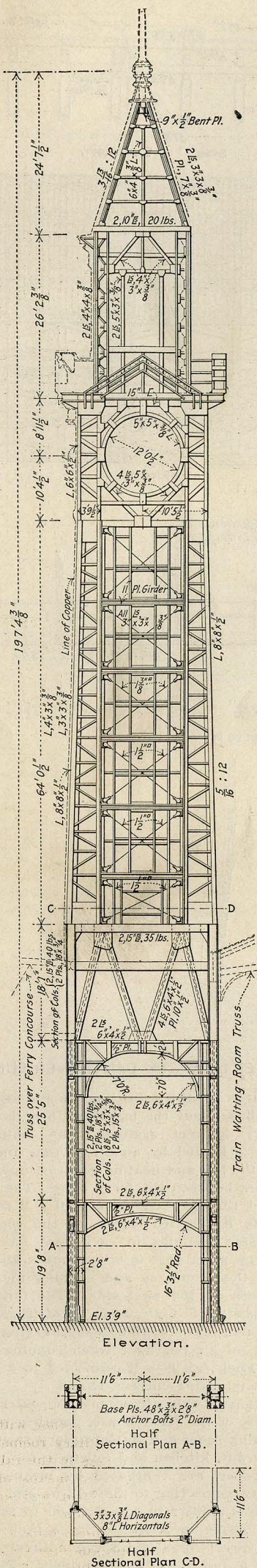


Fig. 9. Framing of Tower (North Elevation).

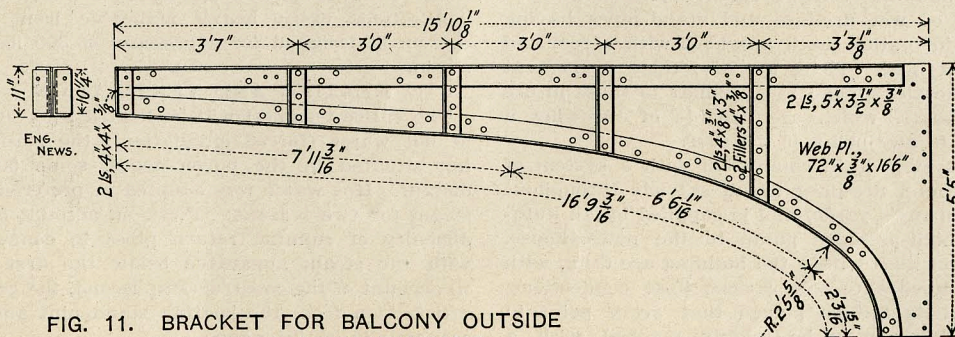


FIG. 11. BRACKET FOR BALCONY OUTSIDE EAST WALL OF RESTAURANT.

tical and supported on a special drop forged ball bearing. The heating of the main waiting-room is controlled by means of the Johnson thermostat automatic regulation.

ELECTRICAL WORK.

High-tension, 2,200-volt, three-phase, 60-cycle alternating current will be generated at the company's power-house (600-ft. distant) and brought to two high-tension switchboards, where it will be reduced to 230 volts by means of single-phase transformers connected three-phase with half voltage taps, six bus-bars being therefore arranged on the switchboards for the lighting, which will supply three-wire circuits having 230 volts between outers. For the motors, the supply is three-phase three-wire. One switchboard will be located under the inclined concourse and will supply all that part of the building referred to as the railroad station, while the other, located in the ferryhouse, will supply that portion. A motor-generator set is also provided in connection with the railroad station switchboard for supplying direct current at 125 volts for the four ventilating exhaust fans and for the elevators. From the two main switchboards current will be distributed by means of 44 panel boards to the various motors and lights throughout the building.

LIGHTING.—The plans provide for about 6,500 incandescent lamps in the terminal. Of these 1,400 are employed in the five large electric signs; one having letters 6 ft. high, surmounting the river elevation of the ferryhouse, and four with 4-ft. letters on the sides of the tower. These signs are backed with steel plates perforated for the lights. Each light is set in a watertight receptacle which is attached to the plate from the back by a special device and furnished with flexible conductors. The lamps can thus be removed from the back, which will effect large saving in the cost of maintenance of the signs.

The four clock-faces in the tower will be illuminated with incandescent lamps and reflectors, the dials being glass.

About 880 lights will be employed in decorative lighting on the exterior; the arches and imposts of the ferry slips on the east elevation, the pediments of the west elevation of the ferryhouse and the cornice of the north elevation of the railroad station being outlined with lights placed in Federal sign receptacles.

The street front of the terminal and the train concourse is illuminated with twelve-light fixtures placed on the trusses of the marquise and concourse roof from 16 to 33 ft. on centers. The team-concourse on the first floor will be illuminated with 59 arc lamps.

About 3,900 lamps will be employed in interior lighting. Of these, 944 are in the main waiting-room, giving lighting power of 1.68 c. p. per sq. ft. of floor, or .032 c. p. per cu. ft. of space. These are so distributed as to fully illuminate the whole room and also to give ample light for reading on the seats. The ferry concourse on the second floor will have 0.31 c. p. per sq. ft. of floor area and .011 c. p. per cu. ft. of volume. It was not considered necessary to illuminate these concourses as brightly as the waiting-rooms, since they are used merely as passageways between trains, boats and the street.

An emergency gas system is provided for the case of breakdown of the electrical system. A few lights only are placed in each room, the intention being not to fully illuminate the building but merely to provide without delay sufficient light to handle the passenger traffic, and prevent panic and allow necessary business to be carried on.

TELEPHONE AND TELEGRAPH.—Two complete telephone systems will be installed, one for the Commissary Department and one for the Operating Department. These are to be of the intercommunicating type and will connect all the offices and rooms of these respective departments. A complete interior conduit system for public telephone and telegraph is also being installed, so that all of this work can be run concealed.

Each of the more important rooms and the tower will be provided with a clock, there being 28 in all, operated electrically by a master clock system controlled from the U. S. Observatory in

Washington. The tower clock has four faces each 12 ft. in diameter.

PLUMBING.

As the building stands over the water there is no main sewer line, but each soil and waste line empties direct into the river with a flap valve at the outlet to protect the traps from cold. Traps below the first floor were avoided on account of the danger of freezing, but in some cases where traps were necessary the steel beams are set a foot below grade and the space filled up with cinder concrete, in which pipes and traps are placed. Throughout the first floor each fixture discharges individually into the river, and siphonage of traps is prevented by mercury vents, no other venting being necessary. On the second floor each group of fixtures has its own soil and waste lines and stack, and the traps are vented in the usual manner. Except as modified by local conditions as described above, all plumbing work is installed as required by the rules and regulations of the Bureau of Buildings of the City of New York.

The following is the list of principal plumbing fixtures to be installed in the entire terminal:

Water closets	69
Lavatories	68
Urinals	37
Slop sinks	12
Bath tubs	3
Shower baths.....	5

All lavatories, slop sinks and kitchen sinks are provided with hot water, two Tobey water-heaters being provided for that purpose.

A very copious fresh water supply is provided, since all the ferryboats take water for their boilers while in the slips. The water mains in the ferryhouse are 6-in. and 4-in., and two tanks of 1,200 and 4,000 gals. capacity are provided in the attic space to insure uniform pressure and the quick delivery of a large quantity of water to the boats. Hose bibs are placed at frequent intervals throughout the team and train-concourses for cleaning purposes. The water system for the supply of boats and fixtures is entirely separate from the fire system described above, and is connected with the city mains.

FERRY LANDING BRIDGES.

The main ferry bridges, on the first floor, to which the ferryboat is made fast, are constructed of wood in the usual manner (see Fig. 12). The forward end of each bridge is supported by a pontoon, and is further suspended from the second (transverse) roof-truss of the slip by chains passing around overhead sheaves and operated by windlass on the bridge deck. At the rear end the bridge is hinged to the forward end of a double buffer-platform supported on piles, driven close together. The impact of the ferryboat is taken up by the inertia of these platforms and the resistance of the piles; the platforms are separated from the floor of the building proper by a 6-in. air space covered with a sliding plate.

From the balconies opening from the ferry-concourse passengers pass over bridges to the upper deck of boats. These bridges are for part of their length rigidly hung from the trusses above, but the outer sections are supported from the pontoon bridge below and rise and fall with it [the mean fall of tide between high and low water is 5 ft.]. The supporting device is the invention of the consulting engineer of the work, Mr. E. W. Stern, who has applied for patents. The outer end of the overhead bridge is 24 ft. beyond the point of support on the pontoon bridge, while the length of the suspended span is much less than the length of the pontoon bridges. This necessitates some sort of compensating device to make the rise and fall of the outer ends of the two bridges the same. The movable portion of the upper bridge is in three sections, as will be seen by reference to Fig. 13. The inner section is a simple girder span pin connected at each end. The middle section is a cantilever construction supported on posts, pin-connected at the bottom to a shoe on the pontoon bridge, and at the top to the girder span, which thus acts as a link to hold the cantilever up. The outer section is a so-called apron bridge, pivoted, and balanced to work by hand, and operated by the deck-hand on the boat. Its purpose is that of an ordinary gang-plank. It will be noted that in the operation of

this structure the floor of the cantilever span remains practically horizontal and the pin of the apron bridge moves vertically the same height as the pin at the bottom of the post.

It will be noticed that there is a heavy bracket on the back of the post under the girder span, but in no way connected to it, and that the shoe at the bottom of the post is arranged to slide on a track. The object of this is to furnish a safeguard in case of accident due to the boat getting out of control and ramming the pontoon bridge with sufficient force to unseat it from its bearings [this has happened] and drive the bridge back on the ferryhouse floor for a considerable distance. Such an accident would result in a serious disaster if the pin at the foot of the post were immovable, since the upper bridge would crash down on the deck of the ferryboat. With the present device, however, the bracket would engage the girder span and the cantilever span be held up while the shoe slides along the track.

TRAIN SHED.

The train shed was designed by the Chief Engineer of the railway company, and is believed to be of an entirely new type. The defects inherent in the wide-span train shed and its great initial and maintenance cost are well known, and after considering several designs of steel arches of various span and types, it was decided to abandon the wide arch entirely and employ some form of open umbrella shed. As it was the intention to place the tracks in pairs to reduce the number of platforms, an umbrella shed of the usual type would necessitate a wide opening between the sheds, and to avoid this undesirable feature the present shed was designed. The essential features, Fig. 14, are a low roof of glass and concrete supported on steel trusses and a narrow continuous opening with aprons at the side extending as low as the smokestack of an engine, so that all smoke passes directly out of the shed to the outer air. The details of the construction are shown in Fig. 15. Cast-iron columns placed on the center line of each platform support transverse-arched plate girders. The top section of the column above the neck is cast square and the girders are bolted to the columns with through bolts. The bents are 27 ft., c. to c., and the total length of the shed, including the overhang at each end, is 607 ft. Expansion is taken care of by an expansion joint placed at every other column, that is, every 54 ft. Transversely, there are eight spans of arches, and the columns are 43 ft. 4½ ins. on centers, except the end spans which cover only one track, and are, respectively, 30 ft. 4½ ins. and 35 ft. 10½ ins. between centers of columns.

The smoke opening over each track is formed by a pair of light lattice stringers which are wrapped with expanded metal and cased solidly in concrete, the surface being floated smooth. The portion of each main girder where it crosses the opening is also encased in concrete, so that the smoke and gases come in contact with no steel-work. The aprons formed by the casing of the stringer at the side of the smoke opening extend low enough to catch all the smoke from the stacks. They also are carried a short distance above the roof as parapets and form an effectual protection to the platforms from driving rain. Narrow openings are pierced in the aprons every few feet, just under the roof, to allow the escape of any smoke or gas that may find its way under the shed. A continuous ventilator is placed on the central skylight at the highest level of the roof for a similar purpose.

Connecting each two columns longitudinally is a steel member, built up of two channels and a plate in the form of a trough which serves both as a stringer to support the roof and as a rain water conductor. The water passes off through leaders enclosed in the columns and thence into drains under the platforms. The trough is lined with copper. The shed is braced longitudinally by plate-and-angle braces riveted to the steel trough mentioned above and bolted to the columns in similar manner to the main girders. The braces are built with a curved flange to correspond with the lower chord of the main (transverse) girders, and the four members springing away from the

