INTERCEPTING SEWERS.

CHAPTER VI.

INTERCEPTING SEWERS.

As before stated, and as shown by the plan (Plate V.), the South Boston intercepting sewer is the first to join the main sewer in the latter’s course from the pumping-station towards the city proper. This intercepting sewer, by its two branches, is intended finally to encircle the peninsula on which South Boston is situated, and intercept the sewage flowing in the common sewers, which have heretofore discharged their contents at nineteen outlets, in the immediate vicinity of a dense population.

At the point of junction the grade of the intercepting sewer is 1.5 feet higher than that of the main sewer, so that the sewage in the former shall not be dammed back, and the established rate of inclination shall be maintained on the surface of the sewage in both sewers at the time of maximum discharge. In all cases where a main-drainage sewer joins another the junction is made at a “bell-mouth” connection chamber, in which the axes of the sewers meet by lines or curves tangent to each other, so that the two currents may unite with the least disturbance to either. Sections of the “bell-mouth” junction of the two branches of the South Boston sewer, at Hyde Street, are shown by Fig. 14, Plate VII. On each intercepting sewer, just before it reaches the main sewer, is built a penstock chamber, containing a cast-iron penstock gate, by which the flow can be cut off, so that the main sewer can be entirely emptied, should it ever be desirable to do so. At such times the city sewage would be discharged at the old outlets, which are all retained and protected by tide-gates. A sketch of the penstock on the South Boston sewer is given by Fig. 6.

Up to where it divides this sewer is circular, six feet in diameter. The average depth of excavation was 20 feet. Clay or sand was usually found, and the sewer consists of a simple
ring of brick-work, 12 inches thick, though for about 350 feet, where the sand was wet and inclined to run, abutment walls of rubble masonry were used. Figs. 12 and 13 show cross-sections of this sewer. The brick invert was laid with Portland cement mortar, one part cement to two parts sand, and the arch was laid with American (Rosendale) cement mortar, one part cement to 1.5 parts sand. This was the common practice in building the main drainage sewers, Portland cement being used in the inverts, on account of its greater resistance to abrasion. When Rosendale cement was used for building inverts, the proportion required was equal parts of cement and sand.

The inclination of this sewer throughout the greater portion of its extent is 1 in 2,000, which affords a velocity of flow sufficient to prevent deposits of sludge, but not sufficient to keep in suspension sand and road detritus. A sharper inclination would have been desirable had it been practicable to obtain one. Few of the main drainage sewers have a greater inclination than 1 in 2,000, and it was expected from the first that flushing would occasionally be required to prevent the accumulation of deposits. To provide for this, iron flushing-gates are built into the sewers at intervals of about half a mile. The first flushing-gate on the South Boston sewer is just below the fork at Hyde Street. A sketch of this gate is given by Fig. 15. Usually the gate stands above the sewer, in the man-hole. It is kept vertical by two small stop-bolts at its top. To flush the sewer the gate is lowered against its seat, built into the bottom of the sewer, and the sewage accumulates behind it as deep as the gate is high. The stops are then withdrawn and the gate raised until it clears its lower seat, when it tilts over into a horizontal position and opens a free passage for the dammed-up sewage.

The greater part of South Boston is high land, and there are but few low cellars there which are subject during rain-storms to flooding at high tide. In order that the full capacity of the sewers and pumps might be available to relieve other parts of the city, less favored in this respect, it was necessary to arrange that no more than a fixed quantity of sewage should ever be received by the main sewer from the South Boston
intercepting sewer. To accomplish this a "regulator" was built into the intercepting sewer just below its last connection with a common sewer, at Kemp street.

A sectional plan and elevation of this machine, and of the chamber containing it, is given by Fig. 9, Plate VII. As will be seen, the apparatus is very simple, and consists of stop-planks, closing the sewer from its top down to about the ordinary dry-weather flow line, the sewer below the planks being lined with a cast-iron gate frame, or seat, curved to fit the invert, and also vertically to correspond with the curve of motion of a cast-iron valve, which plays up and down in front of it. The valve is held by two cast-iron levers, pivoted by a 3-inch wrought-iron shaft in two bearings, the other ends of the lever being connected by vertical arms to a 3-inch square bar. To the ends of this bar are fastened two boiler-plate floats, placed in wells on either side of the sewer. To avoid disturbance to the motion of the floats, by waves caused by the rush of sewage under the valve, water is brought to the wells through a 5-inch pipe, as shown, from a point 50 feet below the regulator.

The connection between the valves and the floats can be so adjusted that the former will begin to close when the surface of sewage in the sewer has reached any desired height. As the floats rise the valve descends until the opening below it is just sufficient to let enough sewage pass to maintain the allowed depth of flow in the sewer. Should the amount of rain-water from low districts, reaching the main sewer through other intercepting sewers, exceed the capacity of the pumps to control it, the main sewer fills, and its sewage backs up into the South Boston sewer, and still further raises the floats. The opening under the stop-planks is thus entirely closed, and all of the common sewers above discharge at their old outlets, and continue to do so until the amount of water reaching the pumps can be controlled by them.

Above where this sewer divides, at Hyde Street, the branch which turns to the right, and skirts the southerly margin of South Boston, is egg-shaped, four feet six inches high by three feet wide (Fig. 11, Plate VII). After passing under the
Old Colony Railroad the shape is changed somewhat (Fig. 3). At Vinton, Vale, and other streets, common sewers are intercepted. Fig. 7, Plate VII., shows the connection with the Vale-Street sewer, and may stand as a type of such connections between common and intercepting sewers, wherever no regulation of the amount to be received from the former is required. Nearly every individual case presented special conditions, which necessitated some modification of the method of construction; but the general plan was the same in most cases, and its features are shown in this case.

A sump hole, two feet deep, into which the sewage falls, is first built in the common sewer. Into the bottom of this sump is built a short section of iron pipe (Fig. 5), from 12 to 24 inches in diameter, protected by a cast-iron flap-valve. Ordinarily this valve stands open, but can be closed if it is desired to break the connection between the two sewers. The bottom of the sump, around the pipe, is rounded off with strong Portland cement concrete, so that there shall be no corners in which deposits can lodge. The sewage passes to the intercepting sewer through a short branch connecting with the lower end of the iron pipe.

Beyond the sump the common sewer is provided with a chamber containing a double set of tide-gates. These gates give a clear opening of from two to four feet diameter. Each set of gates is hinged to a cast-iron ring, or gate seat (Fig. 8), which is built into the brick-work. The two wooden gates close against each other. To make tight joints the bearing surfaces of the gates are covered with strips of rubber about three-eighths of an inch thick. The gates are inclined somewhat, so that they are self-closing.

From the main sewer to the Old Colony Railroad this intercepting sewer was built by contract, at an average cost of $12.68 per lineal foot. From the railroad to H Street it was built by day's labor, and cost $13.25 per lineal foot. On Ninth Street, between Old Harbor Street and G Street, for a distance of about 800 feet, the sewer location crossed a bench which was several feet below high-tide level. No coffer dam or other protection was used in this place, but construction was carried
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on only when the tide was down. When the sea rose it over-
flowed and filled the trench. When it again fell the water in
the trench was let off, through the sewer already built, to pumps
at the pumping-station, and work was resumed. From II
Street to N Street, on Ninth Street, the sewer was built by
contract. For about 1,000 feet, near K and L Streets, the
average depth of the trench was about 27 feet. The sewer was
nearly circular, three feet wide and three feet two inches high
(Fig. 1, Plate VII.). This section was among the earliest built,
and its design is not in accord with later practice. It might have
been made more convenient for workmen to enter, at slight
additional expense, by giving it a greater vertical diameter. Its
fall is 1 in 1,666¾.

From the point of division on Hyde Street the sewer which
turns to the left, and follows the westerly shore of South Boston,
is egg-shaped, five feet six inches by four feet nine inches, up to
the Old Colony Railroad crossing, on Dorchester Avenue. A
timber platform and rubble masonry side walls were required for
the entire distance, and the usual cross-section of this sewer is
shown by Fig 10, Plate VII. This section was built by con-
tact. Its length is 3,350 feet; the average depth of excavation
was about 24 feet, and the average cost per lineal foot was
$16.85.

After taking in the B-Street sewer the intercepting sewer
changes its shape (Fig. 3), and continues in Dorchester
Avenue, passing under the N.Y. & N.E. Railroad, and turns
into Foundry Street, which it follows to its end, at the corner
of Dorchester Avenue and First Street. Considerable difficulty
was encountered in passing under the abutments of the bridge
on Dorchester Avenue, over the N.Y. and N.E. Railroad.
These were underlaid by running sand, and the northerly abut-
ment over the sewer, which had been built without mortar, had
to be taken down. Under the tracks of the same railroad,
head-room being limited, the shape of the sewer was altered
(Fig. 2), so that there should be no danger of its interfering
with, or being injured by, repairs to the road-bed. This section
of sewer is 2,820 feet long, and its average cost per foot was
$19.25.
The second large intercepting sewer which enters the main sewer, had its point of connection at the intersection of East Chester Park and Albany Street. It is called the East Side intercepting sewer, and is located in streets following the easterly margin of the city proper for a distance of about 2½ miles. In Albany Street, from East Chester Park to Dover Street, a distance of 4,524 feet, the sewer is nearly circular, with a vertical diameter of five feet eight inches, and a horizontal one of five feet six inches. The inclination is 1 in 2,000. The average depth of excavation for this section of work was 24 feet, and, as marsh mud and peat extended from near the surface of the ground to a depth always considerably below the bottom of the sewer, piles were required to furnish a secure foundation. A timber platform was fastened to the tops of the piles, and on the platform the sewer, with its rubble masonry abutment walls, was built. The bottom of the excavation was about 6.5 feet below the elevation of low tide, and considerable trouble was experienced from sea-water making its way into the trench, especially in places where old sea-walls and other such obstructions were encountered. The mud on the sides of the trench exerted much lateral pressure, and close sheet-piling and heavy bracing were necessary. Opening so deep a trench in such material drained the water out of the adjacent soil, rendering it spongy and somewhat compressible, so that the whole street settled and had to be resurfaced and repaved. This section was built by contract. One firm of contractors gave up the job, and the work was re-let under provisions of the contract. The average cost per lineal foot of the completed sewer was $28.16.

The first common sewer taken in by the interceptor is that on Concord Street. This sewer drains a district in which the cellars are not subject to flooding from rain-water during high tides. It was not necessary, therefore, to let this sewer discharge into the interceptor an amount of sewage in excess of its ordinary maximum dry-weather flow, and temporarily, during rain storms, the whole dilute contents of the sewer could, without injury, be permitted to discharge into the bay at the old outlet. An arrangement to effect this was desirable, because, during very heavy rain-storms, the whole capacity of the inter-
ceping sewer might be needed to afford relief to sewers drain-
ing low districts beyond Concord Street.

Accordingly the connection between this sewer and the intercepting sewer was made through a chamber containing a small regulating apparatus, designed to control or cut off the flow automatically. Figs. 1 and 2, Plate VIII., show sections of this apparatus and its arrangement. Eight similar appliances, with slight modifications in the methods of arrange-
ment, were used in connection with the same number of common sewers.

The operation of the apparatus will be understood from an examination of the figures. Under ordinary circumstances the sewerage falls into a sump, and thence passes to the regulating chamber, which it enters through a cast-iron nozzle. This nozzle is circular, 12 inches in diameter at its upper end, and rec-
tangular 20 × 6 inches at its orifice. In front of the orifice plays a cast-iron valve, moved by a float in a tank set in the floor of the chamber. The water in the tank stands at the same elevation as that in the intercepting sewer, a 4-inch iron pipe connecting one with the other. The apparatus can be adjusted so that the valve will begin to close and cut off the flow of sewage when the water in the intercepting sewer reaches any desired depth. When not cut off, the sewage flows around the tank and passes on through an opening at its further end.

The second common sewer taken in is that in Dedham Street. This sewer drains a district which used to suffer greatly from flooding during rain-storms. In order to afford relief this sewer was connected directly with the interceptor by a branch two feet in diameter, the inlet to which is never closed.

The third sewer taken in is that in Union Park Street. The district drained by it has suffered but slightly from wet cellars, and that only during severe storms and very high tides. The flow from this sewer was regulated in the same manner as that from the Concord-Street sewer, but the apparatus was so adjusted that it cuts off the flow later than in the case of most other sewers, and only when the intercepting sewer is nearly full.

The fourth common sewer met with is that in Dover Street.
This drains a low district, and a free connection, two feet in diameter, was made with it. According to the usual practice in such cases this sewer would have been connected with the interceptor at or near the point in Albany Street where their two locations intersect. But it was found in examining the city sewers, with reference to connections with them, that the Dover-Street sewer was not in condition to be intercepted at any point east of Harrison Avenue. Between that street and its outlet it is a rectangular wooden structure, 5 × 6 feet in dimensions, placed close to an old stone retaining-wall and surrounded by loose stone ballast. It is considerably broken, so that the tide-water from the bay which ebbs and flows about the wall and in the ballast has free access to the sewer, and would have flowed into the intercepting sewer, and so reached the pumps. From Harrison Avenue westerly, the Dover-Street sewer was built of brick, and was tight so that seawater could be excluded from it by tide-gates. Accordingly the connection was made west of Harrison Avenue, and a 2 × 3 feet oval branch sewer (Fig 3), 585 feet long, was built from that point to convey the sewage to the intercepting sewer at Albany Street.

Above Dover Street are few districts which suffer from flooding. Accordingly a large regulating apparatus, to control the flow from above, was built into the intercepting sewer at this point. It resembled that on the South Boston sewer, before described, and shown on Plate VII. by Fig. 9.

From Dover Street to its upper end on Atlantic Avenue the East Side sewer was built by day’s labor, under a superintendent appointed by the city. This was done because above Dover Street the sewer location was confined to crowded thoroughfares, in which peculiar management was required to prevent serious obstruction to travel and to the business of abutters; and also because, operations being principally carried on in filled land, beds of dock mud, old walls, wharves, and other obstructions were continually encountered, requiring frequent changes in methods of construction which could not be foreseen and provided for in the specifications of a contract.

From Dover Street the sewer location extends in Albany
Street to Lehigh Street, at which point it enters private land, and crosses the freight and switch yards of the Boston and Albany, and Old Colony Railroads, to Federal Street, near the bridge, a total distance of 2,331.5 feet. In Albany and Lehigh Streets are the tracks of a Freight Railway Company, and in the railroad yards are about 40 lines of rails in constant use, which it was very important should not be disturbed. The whole section of work is in filled land, underlaid by beds of mud from 5 to 20 feet deep, below the bottom of the sewer, which is itself several feet below the level of low tide. At different points obstruction in the shape of old walls and wharves were encountered, which admitted sea-water freely to the trench, so that, as a rule, work could only progress during low stages of the tide.

The sewer is oval, five feet high (Fig. 4), and generally required piling for its support. It is built partly of wood, lined with two inches of concrete, and partly of brick-work resting on a solid cradle of wood, six inches thick. Travel upon the streets was not interrupted, and with considerable difficulty the freight-railway tracks were supported and maintained. As it would have been impossible to have had an open trench through the Albany and Old Colony Railroad yards without interfering with their traffic, operations at that point were carried on entirely below the surface. The tracks were supported by stringers, and the spaces between them floored over. By the use of special machinery all the earth excavated or refilled, as well as materials for constructions, was conveyed by tracks suspended below the floor. The trench was well braced, and its sides protected by lag-sheeting, which, together with the piles driven to support the sewer, were all put in place without encroaching upon the surface. It is believed that not a single train was delayed, nor any inconvenience caused, by these operations. The average cost of this section of sewer was about $31.26 per lineal foot.

In Federal Street, and Atlantic Avenue to its end at Central Street, the intercepting sewer is oval, four feet six inches high by two feet eight inches wide. Fig. 5, Plate VIII., shows the usual mode of construction. Federal Street contained double horse-
railroad and single freight-railway tracks, and beneath its surface were one sewer, two water pipes, and two gas pipes. Beds of dock mud extended from 5 to 20 feet below the bottom of the new sewer, and old dock walls and timber structures were frequently encountered. A location on the east side of the street was found to be most practicable, and the sewer was built by methods which left the roadway open for travel. By flooring over the trench at intervals, passages were maintained through the excavating machine (shown on Plate XXV.) to the yards and wharves bordering Fort Point Channel.

The freight-railway tracks were shifted towards the centre of the street, and were used during the day for the passage of horse-cars in one direction. Bricks, cement, and other material were piled on the outer edges of both sidewalks where they would cause least inconvenience, and always so as to leave a clear passage-way four feet wide. Endeavors were made to cause the least possible annoyance to corporations and individuals; and in general these efforts seemed to be appreciated and reciprocated by the public, so that complaints were rare. This section of work was 5,159 feet long. The average depth of excavation was about 21 feet, and the average cost of completed sewer was $15.06 per lineal foot. The Stony-Brook intercepting sewer joins the main sewer at the intersection of Camden and Tremont Streets. This sewer intercepts the sewage which formerly emptied at seven outlets, into Stony Brook, and thence found its way into the Back Bay. In Tremont and Cabot Streets, from Camden to Ruggles Street (Plate V.), a distance of 2,135 feet, the sewer was built by contract. The rate of inclination is 1 in 700, and the average depth of excavation required was 21 feet. The sewer is nearly circular, four feet six inches wide by four feet eight inches high, and is chiefly founded on clay, so that side walls were only needed for about 300 feet, and the average cost per lineal foot, including inspection, was $11.97. The customary iron penstock gate was built into the sewer just above the bell-mouth connection chamber by which it joins the main.

As the territory drained by the sewers which empty into Stony Brook is high land, a large automatic regulating appara-
tus, similar to the one shown on Plate VII., was built into the intercepting sewer at Ruggles Street, by means of which the flow is partly or wholly cut off during severe and continuous rain-storms. Above the regulator is a three-way bell-mouth chamber (Fig. 10, Plate VIII.), from which radiate three principal branch sewers. The centre or main branch about 4½ feet in diameter, is 1,700 feet long, and intercepts the sewage formerly discharging into the brook by outlets at Elmwood and Hampshire Streets. This sewer passes twice under the brook, at so low an elevation that it preserves its regular grade and shape. The other two branches are built just large enough to enter, being 2 × 3 feet, egg-shaped, with the smaller end down. These also cross twice under the brook, at Tremont Street and at Ruggles Street. Including the regulating chamber, and all sewers above it, this section of work was built by the day, under the City Superintendent, Mr. H. A. Carson. There were built in all 4,229 lineal feet of sewers, including 415 feet of 15-inch pipe. The average cost per foot of the whole was $14.30. A considerable portion of the 2 × 3 feet sewers was built during the winter of 1880–81. The sewers were from 14 to 19 feet below the street surface, and the excavation was done by tunnelling from pits about 10 feet apart. The outlets of the city sewers being below the level of high tide, in order to prevent back-water reaching the intercepting sewer, it was necessary to build gate-chambers just beyond the points of interception, each chamber containing a double set of tide-gates.

The last of the large intercepting sewers joins the main sewer at its present end at the intersection of Camden Street with Huntington Avenue (Plate V.). It is commonly called the West Side intercepting sewer, and is located in streets bordering the westerly margin of the city proper, and intercepts the sewage which formerly discharged into Charles River. This sewer is about 3½ miles long, and its inclination from end to end is 1 in 2,000.

From the main sewer to Beacon Street, and in that street to Charles Street, a distance of 9,325 feet, the West Side sewer was built by day’s labor, at an average cost of $13.35 per lineal
foot. This section of work includes, besides the customary
man-holes, six common-sewer connections, five small regulators,
one side entrance, one penstock, and three flushing-gates. The
usual form of this sewer is shown by Fig. 8, Plate VIII. It is
egg-shaped, five feet six inches high by four feet nine inches wide.
It will be noticed that the usual position given to an egg-shaped
sewer is reversed in this case, the larger end of the egg forming
the invert. This position was adopted because, while affording
convenient head-room, it kept the flow line as low down as was
practicable. As the flow in this sewer is always a foot or
more deep, the hydraulic mean depth, and consequently the
velocity of flow, is greater than it would have been had the
smaller end of the sewer been below.

A case of slight injury to this sewer may be worth noticing.
When the sewer was built on the line of Falmouth Street that
street had not yet been filled and graded, and the mud and mat,
which underlay the marsh surface in that locality, sometimes ex-
tended down below the top of the sewer. About a year after-
wards the street was graded with gravel about seven feet high
above the original surface of the marsh over the sewer. One
side of the street was filled before the other, and the unequal
pressure which resulted was transmitted to the sewer, and
caused its arch to bulge, as shown by Fig. 12. Fortunately the
amount of distortion was not sufficient to endanger the sewer's
stability, and the crack was pointed with Portland cement.

In Hereford Street, for a distance of 282 feet, the sewer lo-
cation passed under a freight-yard of the Boston & Albany
Railroad, in which were about 20 lines of track. Piles were
driven and stringers placed to support these tracks, and nearly
all of the sewer building operations were carried on beneath
the surface of the ground, so that the traffic of the railroad was
not interfered with. At this point, and beyond the railroad
location for a total length of about 800 feet in Hereford Street,
a common sewer was built in the same trench, directly above
the intercepting sewer. This was done by an arrangement with
the City Sewer Department, which designed and paid for the
upper sewer. A cross-section of the two sewers, showing their
arrangement, is shown by Fig. 9.
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In Beacon Street, for a distance of 590 feet in the vicinity of Exeter Street, 22 old stone walls, from five to twelve feet thick, were encountered and had to be cut through. These walls constituted the sluice-way of the old mill-dam, and their removal caused considerable delay. The cost of excavation per linear foot of trench, 20 feet deep in this street, varied from $3.94 to $14.49. The section from Camden to Charles Street was built in 1878. During a portion of the season work was carried on day and night at two different points. The largest number of men and boys employed at any one time was 369. The rate of progress varied greatly; where no special obstacles were met, 108 feet of completed sewer was built each 24 hours.

On Beacon Street the large common sewers in Hereford, Fairfield, Dartmouth, and Berkeley Streets are intercepted. The sewage from each of these sewers passes to the intercepting sewer through a chamber in which is a small automatic regulating apparatus, similar to the one shown on Plate VIII., so adjusted as to cut off the flow whenever the water in the intercepting sewer exceeds an established depth. The sewers just mentioned are too low to pass over the intercepting sewer, and a somewhat different method of construction was necessary in connecting them. The arrangement at Berkeley Street is shown by Fig. 18, Plate VIII.

A secondary intercepting sewer was built in Brimmer Street, which collects all of the sewage flowing westward from Beacon Hill, and conveys it to the principal intercepting sewer in Beacon Street. For the sake of economy and simplicity the old outlets of the common sewers in Revere, Pinekney, Mt. Vernon, Chestnut, and Beacon Streets were abandoned, and the total flow from these sewers, including rain, is taken by the new Brimmer-street sewer, a single storm overflow being provided at Back Street. The construction of the Brimmer-Street system involved the building of 1,456.5 feet of oval brick sewers, varying from 2 x 3 feet to 3 x 4 feet 6 inches in diameter; also the rebuilding of about 556 feet of common sewers, which were found to be too low or otherwise defective. The flow from the Brimmer-Street sewer into the intercepting sewer in
Beacon Street is regulated in the same manner as that from the ordinary city sewers.

A little beyond Brimmer Street a large common sewer, which comes from the south across the Public Garden, is intercepted. This drains what is called the Church-Street district, comprising low territory, in which are many cellars which used often to be inundated. Sewage from this sewer, therefore, is taken directly into the intercepting sewer without the intervention of any regulating apparatus.

On Charles Street, from Beacon to Cambridge Street, a distance of 1,832 feet, the sewer was built by contract. It is egg-shaped, 4 × 4.5 feet in diameter (Figs. 6 and 7), and cost $10.10 per lineal foot. This was the only section of the West Side sewer which was built by contract. In excavating the trench many of the hollow-log water-pipes of the old Jamaica Pond Aqueduct Company were found in a perfect state of preservation. A house-drain was found which the drain-layer had connected with one of these water-pipes, although the street sewer was but a few feet distant. The log had but three inches' bore, and, of course, led to no outlet.

At the intersection of Cambridge and Charles Streets a large automatic regulating apparatus, similar to the one shown on Plate VII., was built into the sewer, to control the flow from above. The excavation in which the chamber for this apparatus was built was 80 feet square; but, by flooring over the top of the excavation, and supporting the various lines of street-railway tracks at that place, travel was not impeded, all building operations being carried on below the surface of the street.

From Cambridge to Leverett Street, a distance of 2,150 feet, the intercepting sewer is oval, four feet six inches by three feet in diameter. It is of brick-work, eight inches thick, and usually required a timber cradle support. The work on this section presented the usual difficulties met with in excavating through filled land, in the way of old obstructions and the free access of tide-water. By a rather curious coincidence, for a distance of about 500 feet, the remains of an old wharf or bulkhead were found, with longitudinal rows of piles within the trench in such positions that, by cutting them off at the proper elevation, they
served as a support for the sewer, in the place of new piles which would otherwise have been necessary. Seven hundred and one feet, in all of the Fruit-Street and Livingston-Street sewers, which were too low to be intercepted, were replaced by $2 \times 3$ feet oval brick sewers. The private sewer from the Massachusetts General Hospital was also too low to be intercepted. This was found to be a rectangular wooden scow, $2.5 \times 2.5$ feet in diameter, with its bottom at low-tide level. The Trustees of the hospital themselves replaced it with a 10-inch drain-pipe at a higher elevation.

From Charles Street to its upper end at Prince Street, a distance of 3,571 feet, the West Side sewer maintained, with rare exceptions, an even size, of three feet wide and four feet six inches high. The arch consisted of eight inches of brick, and the invert was generally made with four inches of brick resting on a timber cradle, also four inches thick. The common sewer in Lowell Street, which was a large, flat-bottomed wooden scow, was too low to be intercepted. It was accordingly abandoned, and all branch sewers and house-drains were connected directly with the intercepting sewer. To facilitate making these connections the intercepting sewer was located exactly on the line of the old sewer. The top planks of the latter were removed, but its side planks were retained, and the new sewer, with its width reduced to two feet eight inches, was built between them. The flow of sewage was maintained during construction through channels above the floor of the old sewer and below the bottom of the new one, which was supported on timber saddles (Fig. 14, Plate VIII.).

Causeway Street is one of the most crowded thoroughfares of the city. It contains two lines of track for horse-cars and one for freight-cars. On its north-westerly side are the depots of three railroads, with no outlet for their passengers and freight except into this street. The tracks of another railroad cross the street. The territory traversed by the street is all made land, consisting of loose materials filled upon a mud bottom.

It was with some apprehension of trouble that work was begun on this section. The most difficult feature of the work was so to conduct it that travel should not be seriously impeded,
Owing to the skill and care of the superintendent and his subordinates, and to the appliances used for handling the earth and other material, the sewer in this street was built within four months, without closing any portion of the street to travel, and with the minimum of inconvenience to the public. At street-crossings and entrances to railroad-yards, work was carried on below timber platforms, or bridges, without encroaching upon the street surface. In crossing the Boston and Maine Railroad tracks, the excavating apparatus, with its steam-engine, was so elevated as to leave head-room for the passage of trains. Plate IX. is from a photograph taken at this point.

As a precaution, where the foundation seemed insecure, the vertical diameter of the sewer was increased by six inches, so that, should slight unequal settlements occur, the invert may be brought to its true grade without lessening the desired size of the sewer. For about 76 feet, to avoid interfering with the street surface, the intercepting sewer was built entirely within an abandoned common sewer (Fig. 15, Plate VII.). At the upper end of the intercepting sewer, at Prince street, the grade of the invert is about four feet above mean low water, which is the highest elevation of any portion of the Main Drainage System. At this point a direct connection with the harbor has been made, which is closed under ordinary circumstances by a three feet square penstock gate. By opening this gate at the time of high tide the sewer can be thoroughly flushed.
Building the Intercepting Sewer in Causeway Street.