The Harlem Creek Sewer, in St. Louis, Mo., is thought to be the largest concrete sewer built in this country, and the part now under construction is notable for the use of steel centering. The Harlem Creek is a small stream in the northern section of the city, draining a district which is mainly open country. It receives, however, both sewage and the refuse from some industrial establishments, and is also subject to flooding by heavy rains. In view of these conditions, and of the future development of this part of the city, it was decided by the Sewer Department to build a conduit to replace the present open channel. Mr. H. R. Fardwell is Sewer Commissioner; Mr. J. A. Hooke, Assistant Sewer Commissioner; Mr. Ross M. Bristol, Engineer of the Sewer Department, and Mr. S. W. Shinkle, Engineer in Charge. Mr. John King is Chief Inspector. Fig. 1 shows cross-sections of the sewer.

The first section of the sewer, extending from Broadway (at Bircher St.) to the Mississippi River, was built by the Hoffman-Hogen Construction Co., and has been completed this month. It is 2,200 ft. long, with a span of 20 ft. at the springing line, and was built with the usual form of wooden centering. This section is now in use, there being a lateral inlet at its upper end.

The second section, work on which was commenced a few months ago, will be 3,000 ft. long, extending west and northwest from Broadway. It follows the course of future streets, and has two bends or changes of direction in its length of 3,000 ft. The grade is 0.25%. There will be about six manholes, placed at the side of the sewer. This section is 25 ft. wide, with a semi-circular arch, and a total height of 17 ft. from the invert to the crown. It is being built by the Prendergast Contracting Co., of St. Louis.

Work was commenced at the lower end of Broadway, the connection with the first section being closed by a dam of vitrified brick in cement, in order to prevent flooding of the new work by water backing up from the river in time of flood. Below this dam is the concrete inlet by which the stream now enters the first section of the sewer. The excavation averages about 33 ft. wide at top, and ranges from 25 ft. to 50 ft. in depth.

CONCRETE WORK.

The section is uniform throughout. There is a semi-circular roof of 25 ft. span, with vertical sides extending below the springing line for about 1 ft. The invert has a radius of 25 ft., and is faced with a single course of hard-burned vitrified paving brick. This use of vitrified brick is standard in all brick and concrete sewer work at St. Louis. The thickness of the concrete is 14 ins. at the crown of the arch, 26 ins. at the springing, and 6 ins. at the lowest part of the invert. The concrete is made of St. Louis “Red Ring” Portland cement, Mississippi River sand and crushed limestone (4-in. to 2-in. in size); the proportions are 1:2.5 for the arch and 1:3:8 for the invert. It is mixed fairly wet to enable it to be packed closely around the steel reinforcing bars. The reinforcement comprises curved transverse rods near the intrados and extrados of the arch, with longitudinal bars wired to them. Vertical bars are set in the haunches. Twisted bars are used throughout, while Johnson corrugated bars were used in the first section.

The concreting of each 25-ft. length of the arch is done at one operation, no stoppage being allowed until the work is complete. The two cableways (described farther on) deposit the concrete on opposite sides, working backward and forward along the 25-ft. length. A gang at the crown attends to the dumping of the buckets and pushing the concrete down the sides. Two gangs, one on each side, tamp the concrete into place with wooden bars.

STEEL CENTERING.

One of the special features of the construction work is the use of steel centering, the steel structure being collapsed, moved ahead, and expanded as the work progresses. The present centering is 25 ft. long, but another 25-ft. length has been ordered, and it is intended to build the arch in 50-ft. sections. The centering is of the Blaw type, built by the Blaw Collapsible Steel Centering Co., of Pittsburgh, Pa. The weight of the 25-ft. length is about 15 tons. This type of centering has been used extensively on smaller work, but this is the largest diameter that has yet been built.

The centering consists of a steel shell riveted to arched ribs of steel channels. As shown by the view in Fig. 2, the interior framing is composed principally of two sets of truss frames, one on each side. The straight chord of each truss extends diagonally from the crown to the horizontal member at the springing line, and the arch rib forms the curved chord. The web members are secured to the chords by connection plates. These truss frames are spaced 30 ins. apart. On each side of each arch rib is an angle rib having one leg riveted to the side of the channel and the other leg riveted to the shell plates. Stiffness is further secured by an intermediate channel rib between each pair of main ribs. Across the central triangular space, between the two inclined chords of each pair of frames, are placed three horizontal timber struts, in line with the horizontal truss members. These struts carry screw jacks. In
FIG. 1. CROSS-SECTIONS OF THE HARLEM CREEK SEWER, ST. LOUIS, MO.
this way the frames can be extended to give the shell the full diameter, or can be drawn inward so as to contract the diameter and thus free the shell from the concrete arch which has set around it. At the forward end of the shell is a curved bulkhead of steel plates, against which the concrete is laid.

Under the lower end of each row of chords is a longitudinal 24-in. I-beam. These afford ample longitudinal stiffness or rigidity. They are provided with small wheels which run on steel angles spiked to longitudinal timbers laid upon the invert. When in place, however, the I-beams are raised by jacks placed under their ends, in order to give the centering its proper vertical position. They are then supported by the jacks and by blocking while the concrete is being deposited and until it has set. The centering must remain in place for at least three days after concreting, but the actual time depends upon the rate at which the construction of the invert progresses.

When ready to move, the horizontal jacks draw the sides of the shell inward, and (the blocking being removed) the vertical jacks under the I-beams lower the structure bodily about 6 ins., until the rollers rest on the steel angles which form the rails. It is then hauled forward one length by means of a cable. With four laborers, the 25-ft. centering can be collapsed, moved ahead, and set up ready for concreting in less than two hours. It is expected that equally rapid work can be done with the 50-ft. section. The arch is left with a smooth and even finish, free from irregularities of surface. The exterior of the shell is oiled to prevent the concrete from sticking to the steel.

Timber is used to form the outside face of the form at the haunches. The joints between the planks are caulked with clay, and the joints with the steel end bulkhead are closed in the same way to prevent the escape of water and cement when the concrete happens to be very wet.

The excavation is kept well ahead of the centering and a 26-ft. length of the bottom is first built. When the lower part is completed, the reinforcing bars for the invert are set in position, the form is placed, and the concrete is filled in to form the invert of the sewer. The brick lining is also set in place. After this part of the work has set for a sufficient time, the supports for the arch centering are laid upon it, and the centering is hauled forward as described above. Pumps mounted on the centering keep the bottom of the excavation dry.

CONSTRUCTION PLANT AND METHODS OF WORKING.

The upper part of the excavation is in a firm dry clayey soil. The lower 6 ft. is in solid limestone rock, and this rock depth will increase to about 8 ft. Immediately above the rock is a bed of stiff blue clay, which is difficult to handle, as it sticks in the 1/4-yd. bucket of the steam shovel. This is a Little Giant machine, carried on traction wheels. It is now intended to excavate to the rock by means of large clips or scraper buckets handled by a cable from a hoisting engine; and to use the steam shovel to load the rock broken up by blasting. At present the rock is broken by blasting and sledding into sizes small enough to allow of being loaded by hand into skips or buckets. The rock is used for the concrete, and some of it is sold for use elsewhere.

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Fig. 2 is a view of the work in progress. In front is the steam shovel, and beside it is the steel drill used in breaking up the rock bench. In the excavation behind the steam shovel is the steel centering. Behind this again is the end of the completed concrete sewer, partly covered by the back-filling. Overhead are the two cableways which handle the excavated material and the concrete buckets.

Fig. 3 is a sketch of the construction plant, which is of interest for its combination of cableways and narrow-gage industrial railways. It may be noted in this connection that there is an increasing tendency to use railways of this class on construction work in this country, following a practice which has been common in Europe for many years.

The concrete-mixing plant is located permanently at about the middle of the work. A No. 8 Gates crusher is set below the ground, so that the men can feed the stone directly into it. A conveyor carries the crushed stone to the overhead screens, from which the stone passes to a row of elevated bins. Adjoining these is the sand bin. The cement and sand are brought in by railroad cars. The cement (in paper sacks) is delivered into a storage shed alongside the track. The sand is shoveled or dumped into a concrete hopper forming the boot of a bucket elevator which delivers it to the elevated bin. Underneath the bins and extending around to the cement house is a narrow-gage track on which run two small side-dump charging cars. One car is loaded with the proper amount of cement, and then runs under the spout of the sand bin. The other car is filled from spouts under the stone bins, taking stone from different parts of the bins in order to ensure a proper proportioning of the different sizes.

At one side of the charging car track is the concrete mixer. This is a Chicago cube concrete mixer, of 1/4 yd. capacity, and has an elevating charging hopper operated by a cable hoist. The sand, cement and stone are dumped into this hopper, which is then raised and automatically discharges its contents into the revolving cubical box. Water is supplied from an
FIG. 2. STEEL CENTERING FOR THE 25-FT. HARLEM CREEK SEWER AT ST. LOUIS, MO.
(At A are the three lines of struts, with screw jacks for spreading and collapsing the centering.)
FIG. 3. STEAM SHOVEL, CABLEWAYS AND STEEL CENTERING ON THE HARLEM CREEK SEWER WORK.
elevated tank having a long water-glass gage. Graduations (on the tank) at the side of this gage show the quantities of water required for a dry, medium and wet mix. One man at the mixer controls the charging hopper, the mixer, the water supply, and the car elevator noted below.

The method of handling the concrete and the excavated material is of interest, being a combination of narrow-gage gravity tracks and cableways. Extending over the line of the sewer are two parallel Lambert cableways 500 ft. long. From the concrete mixing plant to the head of the cableways is a gravity loop track for Koppel narrow-gage flat cars carrying Koppel bottom-dump concrete buckets of 1 1/4 yds. capacity. The lowest point of the track is at the concrete mixer. When a car has received its charge of concrete (by tilting the mixer), it is pushed forward to a platform elevator which raises it to the head of the gravity track. A man then starts it down a short grade of about 1%, beyond which there is a grade of 0.06% to the level portion near the cableway. Here two laborers check the car in position under the hoist of one or other of the cableways.

The bucket is then lifted from the car and run out to the desired point, where it is lowered and dumped. The empty bucket is run back and dropped upon a car, and the two men then start it on the gravity return track from the cableway to the concrete mixer. At present the distance from the cableway to the mixer is about 800 ft., and there are in all about 4,000 ft. of the industrial railway. A man stationed at the back-filling dump, directs the cableway engineers by signs. Another man, on the platform at the forward end of the cableway, signals the former as to hoisting and lowering movements of the buckets. He also signals the man at the car elevator when to start a loaded bucket of concrete.

The rock from the excavation is used for concrete, as already noted. It is loaded into buckets, which are carried by the cableways to a dumping platform having chutes through which the rock falls into steel side-dump Koppel cars of 40 cu. ft. capacity. The car runs by gravity to a trestle over the rock pile at the crusher. When empty, it passes round a loop to a return gravity track. This ends near the loading point, and a mule hauls the car up a short incline to this point, under the platform. The earth excavated is loaded by the steam shovel into buckets of 36 cu. ft. capacity. These (as well as the large excavating slip screeners already mentioned) are raised by the cableway and carried back to the completed part of the work, where the material is dumped for back-filling.

The excavating and removal of earth, and the removal of rock, are carried on at night. The concreting and rock excavation are done during the day. Arc electric lights are erected on poles along the work. Electric motors are used to operate the rock crusher, elevator and screens, the concrete mixer and its charging hopper, and the car elevator. Current is obtained from the Union Electric Light & Power Co., of St. Louis.
FIG. 4. SKETCH PLAN SHOWING THE ARRANGEMENT OF THE CONSTRUCTION PLANT FOR THE HARLEM CREEK SEWER; ST. LOUIS, MO.

- A = Rock Crusher and Elevator
- B = Elevated Bins for Stone
- C = " " " Sand
- D = Hopper for Sand Elevator
- E = House for Cement
- F = Track for Charging Cars
- G = Concrete Mixer